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Vest Station—Charlotte Water Works

New purification plant of eight million gallons capacity contains several novel features, including rate controller and filter bottom original with the designing engineer. Electrically driven centrifugal pumps will gasoline stand-by engines

By Earle G. McConnell*

Charlotte, North Carolina, with a population of 65,000, boasts one of the finest and one of the most modernly equipped water plants of its size in the country. The new plant is located on a twelve acre tract of land just within city limits. It has a rated capacity of 8,300,000 gallons per day. There is ample space on this tract for two additional units of this size and these will be built as the needs of the city require.

Excavation for the new plant was begun in September 1922 and the plant placed in operation during July 1924. This covers a construction period of twenty-one months with two winter periods. No unusual difficulties regarding excavation or construction were encountered.

*Plant superintendent Charlotte Water Department.

As shown on the general ground plan in Fig. 1, the plant consists of the following units:

The main building, 69 feet by 175 feet, containing the filters, pumping equipment, meter installation, and chlorinators.

Chemical house, 25 feet by 40 feet, three stories in height, containing the office, laboratory, chemical feed machines and raw water controller.

Chemical storage house, located on the railway which the property abutts, with storage space for two car loads of chemicals.

Primary mixing chamber, secondary mixing chamber and coagulating basin.

Elevated storage tank, wash water tank, and surge tank.

Clear water basin.

All buildings are of reinforced concrete construction and are fire proof. The floors are red promenade tile on cement mortar base. The windows are

FIG. 5—VIEW OF FILTER OPERATING FLOOR.

steel sash with factory ribbed glass. The doors and door-frames are veneered with metal. The roofs are asbestos and pitch over a base of water-proofed reinforced concrete two inches thick supported by steel trusses. The section through filter and pump room, shown in Fig. 2, gives a general idea of the type of construction of the buildings.

The raw water enters the plant through the raw water controller, which is located on the ground floor of the chemical house. The function of this controller is to admit raw water into the coagulating basin at the same rate at which the filters are taking water from the basin, thus maintaining a uniform water level in the basins and on the filter. Briefly, this is accomplished by allowing any fluctuation of the water level in this basin to work against a diaphragm which in turn actuates a pilot valve. This valve operates a hydraulic control valve on the raw water line. The construction of this control valve is similar to that of the rate controller valve discribed later. This raw water controller has been operating very satisfactorily; in fact it is seldom necessary to make any further adjustment whatever on the raw water entering the plant.

Also on the ground floor of the chemical house is located the office;. the laboratory and chemical

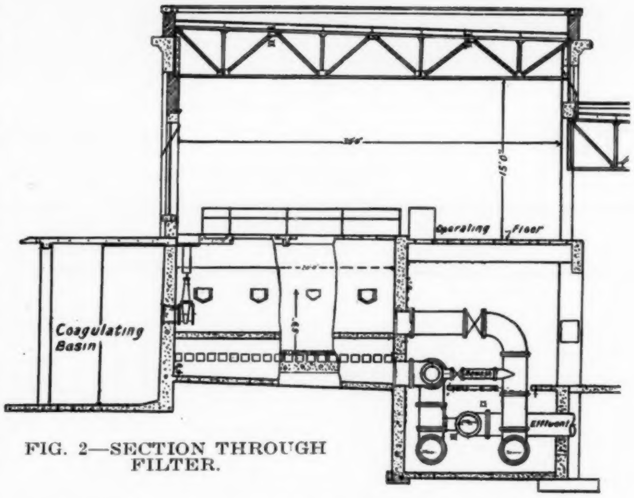


FIG. 2—SECTION THROUGH FILTER.

feed machines are on the second floor, and on the third floor are the hoppers through which the coagulants are fed to the chemical feed machines. There is also storage space on the third floor for a half car-load of chemicals. There is a motor driven one-ton elevator which serves to lift the chemicals to the third floor. The elevator shaft is tightly housed

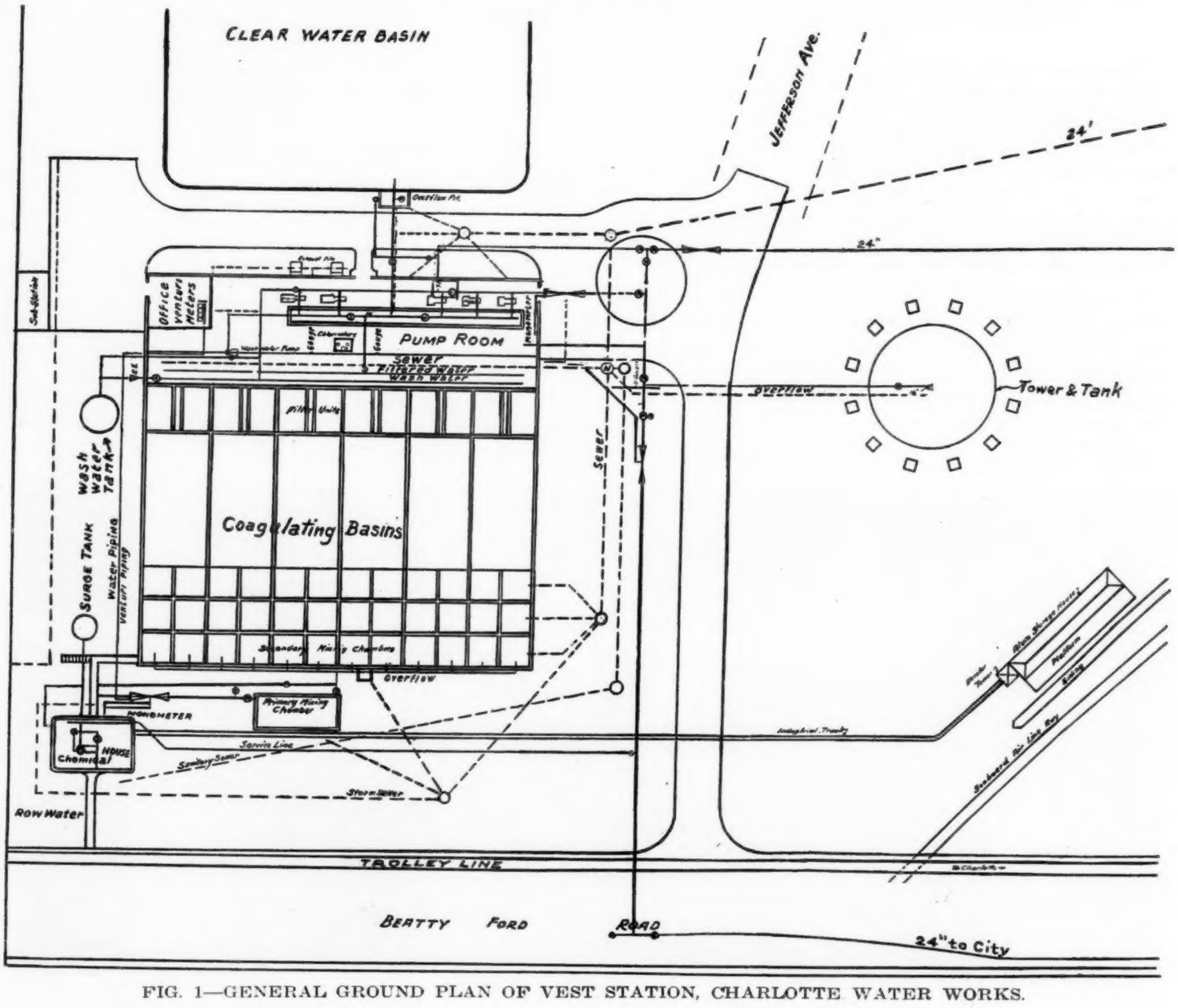


FIG. 1—GENERAL GROUND PLAN OF VEST STATION, CHARLOTTE WATER WORKS.

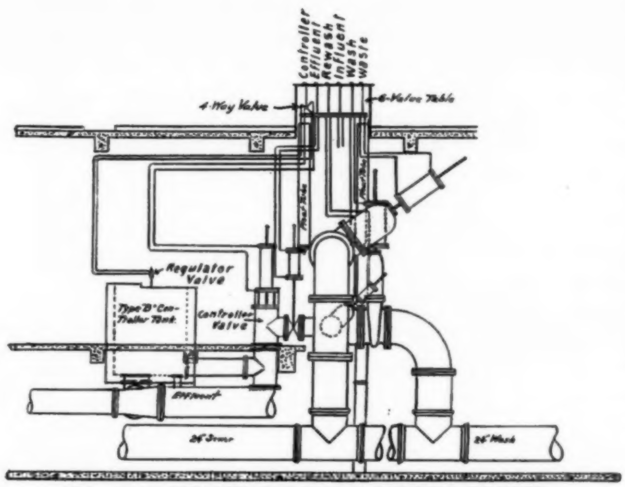


FIG. 2-A—FRONT VIEW OF FILTER PIPING.

with steel partitions to prevent dust from getting through into the building.

Pulverized alum and hydrated lime are used for wheels for operating. At rated capacity there is a retention period of twenty-five minutes and velocity of 0.35 feet per minute in the secondary mixing chamber. The coagulated water flows over a bridge wall from this secondary mixing chamber into the coagulating basin. The bottom of the coagulating basin adjacent to the secondary mixing chamber contains a double row of hoppers of same dimensions as those in that chamber. This gives six hoppers to each compartment, or thirty-six hoppers in the entire basin. This hopper design takes advantage of the fact that the raw water at Charlotte, if properly treated, will coagulate in about ten minutes, so that after the coagulant is thoroughly mixed with the water in the mixing chamber the floc rapidly settles. The greater part of this settling takes place over the hoppers, so that in order to keep the sludge cleaned out of the basin it is only necessary to open the plug valves to the hoppers at certain intervals and allow the sludge to flow into the sewer. The total capacity of the basin is 2,200,000 gallons. At rated capacity of the plant it allows a retention period of five hours at a velocity of 0.304 foot per minute. A

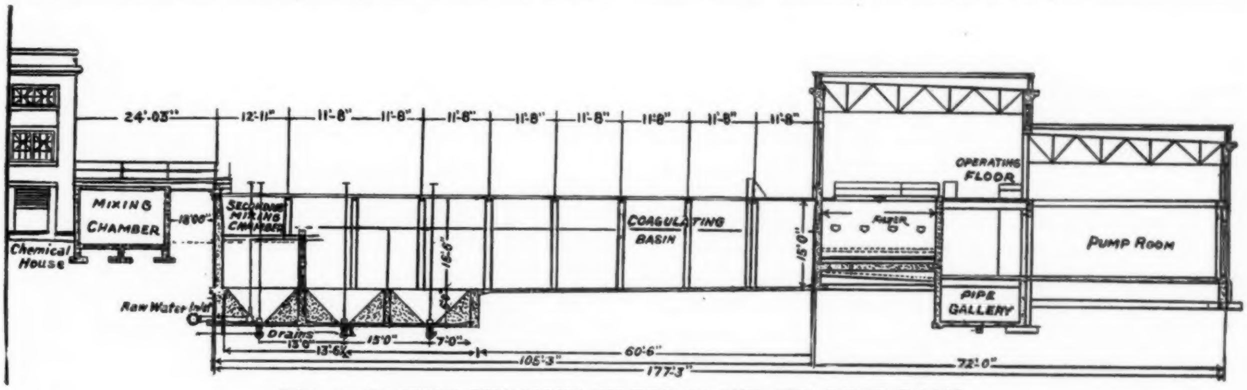


FIG. 3—SECTION THROUGH FILTER PLANT AND PUMP ROOM.

coagulants. There are three Gaunt chemical feed machines furnished by the Roberts Filter Manufacturing Company, two used for alum and one for hydrated lime. The coagulant is added to the raw water between the control valve and the primary mixing chamber.

THE BASINS

The primary mixing chamber is 36 feet by 17 feet by 9 feet 6 inches deep. It contains fifteen around-the-end baffles placed on 24 inch centers. These baffles are constructed of cement plaster on metal lathing. At rated capacity of the plant it allows a mixing period of five and one half minutes at a velocity of 40 lineal feet per minute.

As shown in Fig. 1, the secondary mixing chamber and coagulating basin is divided into six equal compartments, which have no connections between them. Each compartment supplies one filter. The overall dimensions of the secondary mixing chamber and coagulating basin are 105 ft. 3 in. by 175 ft. and a sloping depth of 15 ft. 6 in. at the filter wall to 16 ft. 6 in. at the hoppers. The longitudinal section through plant in Fig. 3 shows the design of the bottom of the basin. The bottom of the secondary mixing chamber in each compartment contains two hoppers with plug valves, which have long stems reaching to the top of the basin on which are hand

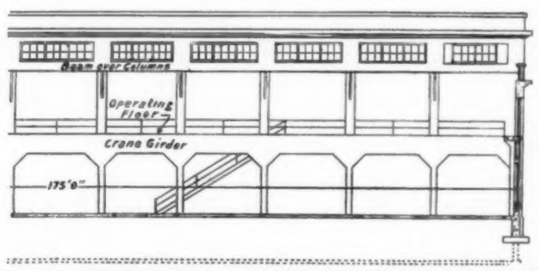


FIG. 3-A—HALF TRANSVERSE SECTION THROUGH PUMP ROOM, LOOKING TOWARD FILTER GALLERY.

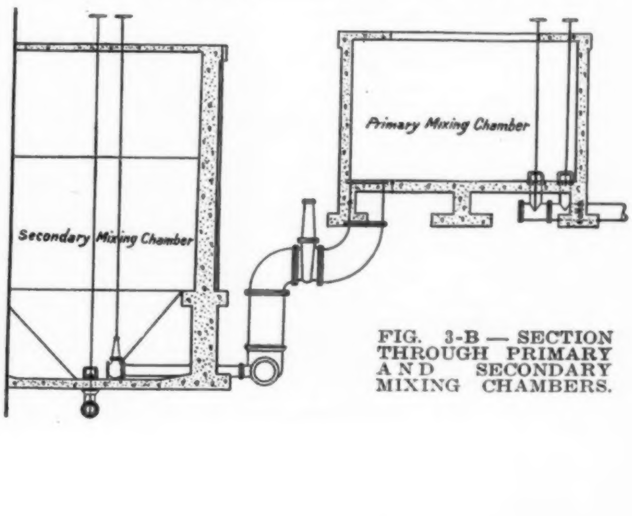


FIG. 3-B — SECTION THROUGH PRIMARY AND SECONDARY MIXING CHAMBERS.

16-inch header runs the width of the basin between the primary and secondary mixing chambers and there are two 8-inch inlets with valves from this header to each compartment of the basin. There is also an overflow on the header which allows any overflow water to go to the sewer rather than over the walls of the basin in case an excess of water is allowed through negligence to enter the plant. The water flows from each compartment directly to its filter through a 16-inch thimble on which is a 16-inch hydraulic influent valve.

THE FILTERS

There are six filters, each filter having two sections, measuring 12 feet by 20 feet, giving each filter a sand area of 480 square feet. They contain 18 inches of graded stone and 27 inches of sand. The rated capacity of each filter is 1,382,000 gallons per day.

One of the features of the plant is the filter bottoms and underdrains. Each filter bottom consists of 160 reinforced concrete slabs 12 inches by 36 inches. Through the slabs pass 3/16 inch glass tubes two inches long, placed in pyramidal depressions on four inch centers. The underdrain system consists of concrete channels, an idea of the design of which may be obtained by referring to the section through filter and pump room in Fig. 2. The slabs are fastened to the underdrains with holding down bars ½ in. by 1½ in. by 12 ft. The slabs and holding down bars are completely grouted in so that no iron or steel is exposed to the action of water or air. Lying on top of the slabs, the bottom of the filter is completely covered with a sheet of double-crimped bronze wire cloth having eight meshes to the inch of No. 20 wire held down with bronze bolts and washers.

The filter operating tables are piano type of polished marble with bronze fittings. In addition to the levers for operating the filter valves they have filter wash-down valves, dial valve indicators, indicating and recording loss of head gauges, and indicating and recording rise and fall gauges. The marble operating tables resting on the red tile floor present a most pleasing appearance.

All filter valves are hydraulically operated and their assembly is shown in Fig. 2-A. The feature of this valve assembly is that it is entirely above the floor of the pump room and does away with the unsightly appearance of having filter valves in a gallery below the level of the floor. The effect of this design may be seen in photograph, Fig. 6, showing the interior of the pump room. Each filter valve assembly consists of a 12-inch filtered water valve, 24-inch wash water valve, 24-inch sewer valve, 4-inch rewash, and a controller valve.

RATE CONTROLLERS

The rate controllers, like the raw water controller and the filter bottoms, are the original design of the consulting engineer who designed the plant. They consist of a concrete controller box with cast iron float and a hydraulic control valve. The whole layout is so designed as to maintain an 18-inch head of water flowing through an orifice. The cast iron float resting on the water surface in the controller box actuates a pilot valve, which in turn operates the controller valve. The entire filter effluent passes through the controller box and orifice. The orifice is adjustable and may be made larger or smaller by a hand wheel on a bronze rod and screw which has an indicator that moves along a calibrated scale. The rate at which the filter is to be operated may be adjusted anywhere from a half million to a million and a half gallons per day by merely changing the size of this orifice.

The controller valve is a hydraulically operated cylindrical plug valve. The valve plug is made up of seamless brass tubing of 12 inches diameter and 1/16 inch thick. It is so designed that the loss of head through the ports is proportional to the distance which the valve is open. In addition to the pressure lines from the pilot valve the controller valve also has a lever on the operating table for opening and closing.

CLEAR WATER BASIN

The effluent from each filter discharges into a header which carries the water to the clear water basin.

The covered clear water basin is 160 feet by 160 feet by 16 feet deep, having a capacity of 3,000,000 gallons. The four corners are rounded. The bottom is 6-inch and the walls are 18-inch

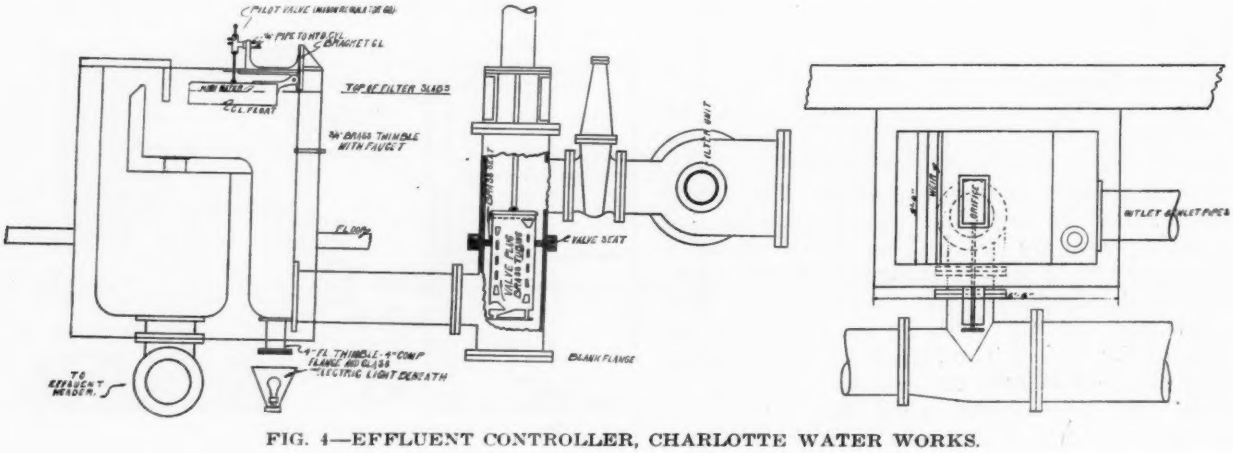


FIG. 4—EFFLUENT CONTROLLER, CHARLOTTE WATER WORKS.

reinforced concrete. The top is flat with enough slope to each corner to allow drainage. It is a 7½-inch reinforced concrete slab supported by 18-inch square concrete columns on 20-foot centers. There are four manholes on the top, each having a steel ladder leading down into the basin. Ventilation is obtained by eight standard 6-inch return bends on the top of the basin. There is an overflow which runs any excess water into the sewer after the basin is completely filled.

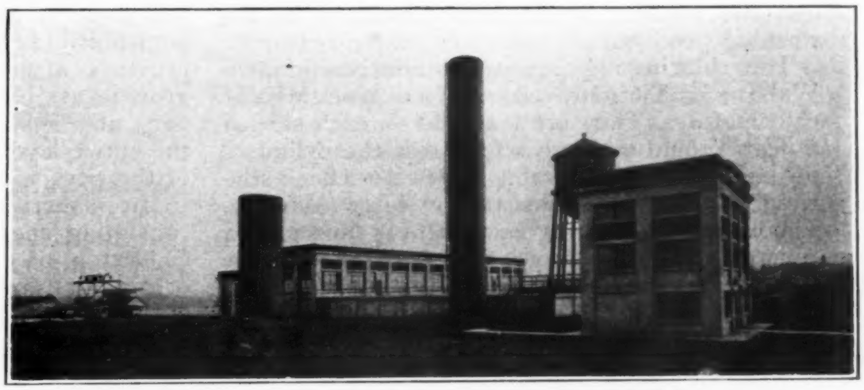


FIG. 7—EXTERIOR VIEW OF THE PLANT.

Both the filters and the clear water basin connect to a 36-inch suction header to which the pump suctions are connected. This header and line to the clear water basin is equipped with valves, as indicated in Fig. 1.

The average requirement of the city of Charlotte is 4,500,000 gallons per day. An average pressure of sixty-five pounds is maintained in the city by a million-gallon elevated steel tank. This tank is a cylinder 56 feet in diameter by 36 feet high with a hemispherical bottom. It rests upon twelve steel piers 104 feet high.

PUMPING EQUIPMENT

The pumping equipment consists of five 4,000 gallon per minute De Laval centrifugal pumps. Three of these pumps are driven by General Electric slip ring induction motors. The other two constitute a standby auxiliary unit and are driven by 300 horse power Sterling gasoline engines. Each pump has a separate 16-inch suction with foot valve and gate valve and a separate 12-inch discharge with gate valve. The layout of the pumps is shown in the photograph of the pump room floor, Fig. 6. The design of the plant permits of doubling both the motor and gasoline engine driven units when the needs of the city may require it, with very little expense except for the units themselves. There is ample floor space left for them and provision made on both the suction and discharge headers so that connections may be made without in any way interfering with the operation of the plant.

Filter wash water is furnished by a standpipe 16 feet in diameter and 50 feet high. A 24-inch line leads from this standpipe to the filter wash water valves. Water is pumped to this standpipe by a 250 gallon per minute motor driven pump. There is also a 6-inch connection to the pressure system, from which the standpipe can be filled in case of emergency.

The surge tank shown in the exterior photograph, Fig. 7, is 10 feet in diameter and 70 feet in height. It connects to the raw water line before entering the plant. The raw water is drawn through a 24-inch main from a 60,000,000 gallon storage basin five miles away, and the function of this surge tank is to minimize any surge or water hammer in the raw water line.

MISCELLANEOUS

The metering equipment consists of four 12-inch Venturi meters, two manometers, and one G. E. flow meter. Of the four Venturi meters one measures the raw water coming into the plant, one the total pump discharge, and the other two are on the two feeder mains to the city. These meters are placed in a row in the meter room in the main building. One manometer indicates the rate of flow of the raw water coming into the plant and is placed near the chemical feed machines in the chemical house. The other manometer indicates the rate at which the pumps are discharging and is located convenient to the motor driven pumps. The flow meter indicates, registers, and records the rate at which a filter is being washed, the amount of wash water used, the hour at which the filter is washed

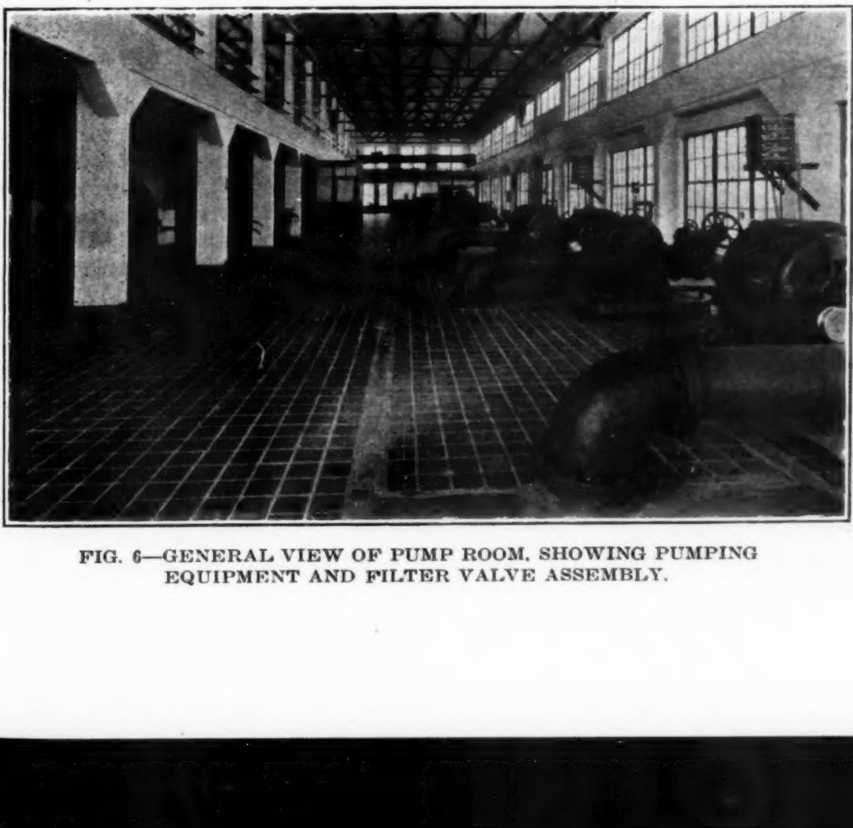


FIG. 6—GENERAL VIEW OF PUMP ROOM, SHOWING PUMPING EQUIPMENT AND FILTER VALVE ASSEMBLY.

and the number of minutes consumed in the washing process.

The chlorinating equipment consists of two Wallace & Tiernan vacuum feed type MSVM chlorinators. They are installed on each side of a neat Toledo scale on which rest the cylinders of chlorine. This scale serves to check the weight of chlorine added to the water each day. The entire chlorinating equipment is housed in a covered steel booth 6 feet by 8 feet. An electric heater inside the booth maintains an even temperature during cold weather.

The plant has been in operation for six months and has measured up to all expectations. It has a splendidly equipped laboratory and is operated under strict laboratory control. Table I gives a general idea of the character of the water treated at Charlotte, and the degree of bacterial removal. Table II shows the doses of coagulants used, the average length of filter runs and the per cent of wash water used in washing the filters.

TABLE I.

Raw Water ,Treated at Charlotte Plant.

Month.	Turbidity Raw	Turbidity Filt.	Alkalinity Raw	Alkalinity Filt.	Ph. Raw	Ph. Filt.	Bacteria per c.c. 37 deg. C. Raw	Coag.	Filt.	Chlor.
Aug.	160	0	16	11	6.7	6.2	105	28	27	2
Sept.	160	0	19	14	6.8	6.3	215	41	12	1
Oct.	250	0	18	12	6.7	6.1	335	44	10	1
Nov.	75	0	17	12	6.7	6.2	115	18	5	1
Dec.	230	0	16	11	6.7	6.0	280	22	5	1
Jan.	340	0	15	10	6.7	6.0	450	50	5	1
Ave.	200	0	17	12	6.7	6.2	250	32	11	1

TABLE II.

Details of Filter Operation, September 1924 to January 1925

Month	Alum Grs. per Gal.	Lime P. P. M.	Chlorine P. P. M.	Length of Filter Runs	Per Cent. Wash Water
Sept.	0.5	0	0.17	85	0.74
Oct.	0.7	0	0.17	70	0.92
Nov.	0.4	0	0.18	68	0.95
Dec.	0.5	0	0.18	86	0.78
Jan.	0.7	0	0.16	154	0.43
Average	0.6	0	0.17	93	0.76

The plant is kept scrupulously clean at all times and numerous potted plants adorn its interior. The walls and ceilings are painted snow white and the concrete work around the filters and floors is painted a buff color. The plant is abundantly lighted both by day and night and presents a most attractive appearance. The grounds are being prepared for grass and shrubbery and when these have become established the entire layout will be one of the beauty spots of the city.

The plant was designed by William M. Piatt, consulting engineer, of Durham, N. C. Tucker & Laxton, of Charlotte, N. C., were the general contractors and the construction work throughout is of the highest type.

On November 12, 1924 the plant was officially designated as Vest Station in honor of Charlotte's veteran water works superintendent, W. E. Vest, who has so long and faithfully served the city as head of its Water Works Department.

Germicidal Action of Ultra Violet Rays

A study of the germicidal efficiency of ultra violet rays has been made by the U. S. Bureau of Standards and reported upon a few weeks ago. The shortest waves were found to have the most pronounced and vigorous action, being capable, when sufficiently intense, of producing death with an exposure of only one second. Longer wave lengths required a greater intensity and acted much more slowly, but some germicidal action was found to result from lengths even as long as 365 millionths of a millimeter, which is almost as long as the shortest waves visible to the human eye. Prior to this experiment doubt had been expressed regarding the ability of these longer waves to kill bacteria.

In making the tests B-Coli were used. Large numbers were placed in the water and after treatment some of this water was spread on to petri dishes to determine the number remaining unaffected by the rays. A quartz mercury vapor lamp was used as the source of the ultra violet rays, screens being interposed to cut off successive spectral ranges of wave lengths. It was found that the intensity necessary for killing bacteria with an exposure of one second or less at a distance of 6 inches from the lamp was that furnished by a 320-watt mercury lamp. When the intensity was very low the germicidal action was greatly retarded, an exposure of 75 to 80 seconds being required in some of the experiments. There was some indication that with some of the lower intensities the bacteria were stimulated instead of being killed.

Tests were made of the relative value of continuous and intermittent exposures, and it was found that the bactericidal effect was proportional to the total exposure whether given all at one time or at successive periods.

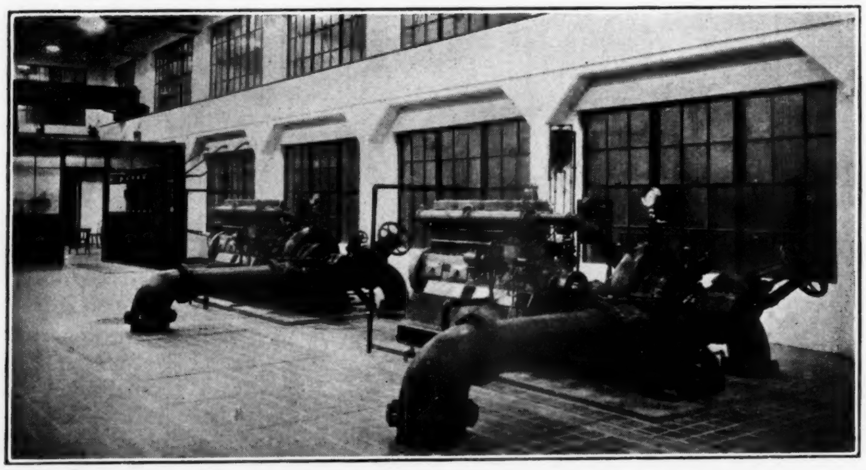


FIG. 8—TWO SIX-MILLION-GALLON GASOLINE ENGINE DRIVEN PUMPS

Breaks in Baltimore Water Mains

Causes of increasing number of breaks, as determined by recent studies by the Water Department. Most cases due to vibration by heavy trucks and disturbance of ground.

By V. Bernard Siems*

It would appear that the number of breaks on water mains in the city of Baltimore has increased in recent years. As there must be a cause to account for this condition, careful studies have been made of each of the breaks lately experienced in order to devise, if possible, a means to overcome such failures. From the observations made and the statistics that have been collected, it can be shown that breaks on water mains constructed of cast-iron pipe result from the following causes:

EXTERNAL FORCES

(a) Vibration from heavy trucks: Especially is this the case where other sub-surface structures have been carried over or under existing water mains, which disturb the earth support on a section of the water pipe. This section of pipe acts as a straight beam (supported at two points) or as a cantilever (supported at one point) and carries the weight of the earth in addition to the load transmitted from the heavy trucks on the surface of the highway.

A break in these cases occurs without notice, and the usual damage is great, provided the water main cannot be shut off immediately.

Vibration tests conducted by the Water Department, with the use of instruments, have confirmed the accuracy of these statements and are of assistance to the Department in the design of future installations.

(b) Opening of joints or loosening of joining material by vibration from electrical railway cars, steam locomotives, and especially heavily loaded trucks: These causes result in the settlement of the pipe at joints, and after a time failure of the section of pipe due to rupture of the joints or unequal support and consequent opening of the joint. These cases commence as a small joint leak, but the number of failures resulting from this cause has been minimized to a great extent by the Pitometer and Water Waste Surveys conducted by the Water Department on the distribution system, by means of which small leaks are readily detected.

INTERNAL OR SUB-SURFACE

Breaks such as mentioned above are less apt to happen after the backfill material in the trench around the pipe has become firmly settled and compacted. In the last 18 years much work has been done in the placing of sub-surface structures—such as sewers, drains, gas mains, electrical conduits, etc.—and there is no doubt that the effect of this work, to a great extent, has been to cause numerous water main breaks. In a number of instances not only have breaks occurred on water mains, but the highway paving has settled as well, due to the disturbance and settlement of the material supporting it by the construction of tunnels.

2. The past practice of supporting bends in a horizontal plane on water mains, with wooden wedges and blocking to prevent movement due to pressure: This blocking in the years has rotted or been disturbed, the support loosens, and movement of the pipe and spreading of joints results. The present-day practice is to place concrete piers behind these bends, where bends are on a horizontal plane, and the strapping of the bends with steel bands encased in concrete where same are on a vertical plane.

3. Defective pipes that are not discovered by the most thorough tests before installation: Cast-iron pipe is subjected to severe tests at the foundry. It is carefully handled when unloading from the cars at the railroad siding, also when distributed at the various places where installations are to be made. The cost of the inspection of this pipe in the foundry varies from 25 cents to 30 cents per ton, with an added expense of testing on the works by Department employees before placing in the trench. It must be borne in mind that cast iron has a longer life than most any other material used as ducts to convey either gases or fluids. In Europe it is known that some cast-iron pipe has been in service 300 years, and is still being used to convey water to the consumers. Some of the largest water mains in the City of Baltimore have an age of 70 years, and the breaks that have occurred on these mains have not been due in any respect to the condition of the pipe, but to external causes.

All cast-iron pipe now installed in Baltimore is in accordance with the American Water Works Association standards as to size and thickness.

4. Deterioration of cast-iron pipe by stray electrical currents (such instances, however, are becoming more rare at this time).

One of the North Avenue mains seems to be the most serious case of deterioration by stray currents from electrical railway system. By co-operation with the electrical railway company, all cases of possible deterioration are minimized by the installation of a return circuit to the substation. It is expected that further failures will be experienced from electrolysis at this location in future years.

DETERIORATION DUE TO ACID IN CINDER FILLS.

In recent years wherever a water main is installed in cinder fills, it is the practice to remove all such material by opening a large area of the trench and placing selected material around the pipe. In fact, such precautions are taken to prohibit the refill of trenches with cinders where repairs have been made. A selected material is always placed over the pipe, and cin-

*Water Engineer, Baltimore, Md.

ders are used only for the upper six inches of the trench backfill to prevent damage to vehicles traveling over the trench by forming a more or less hard surface for traffic. It is assumed that it is hardly possible that from a six-inch covering on the surface the acid will penetrate through the selected material to the cast-iron pipe.

COVERING OF WATER MAINS

The larger size of water mains are being installed to a great depth to prevent the effects of vibration from trucks. The backfilling of the trench around the pipe and over same has been given serious attention; special precautions are taken to see that proper tamping and puddling of the material takes place. The practice is on smaller pipes to place, tamp and puddle the material from the bottom of the trench to a foot above the pipe, this depth varying, however, to a greater amount in the larger sizes of the pipe.

It is estimated from statistics in our files and from information obtained from private water companies and municipal water companies, that 90% of the water main breaks are due to the removing of the support under the pipe for the installation of other utilities' sub-structure, and the vibration partly described in I-(a) and I-(b).

The condition of water mains due to vibration is not as noticeable in the Northern cities as in the Southern cities, because in the Northern cities the depth to which water mains were laid years ago was controlled by the depth to which the frost penetrated, which, of course, is greater in the northern cities than in Baltimore. It is most noticeable in the Southern cities where the water pipes are laid with a very shallow covering. In Baltimore this depth was originally three feet. Vibration over the water pipe has made it practically necessary in recent years to place greater covering on the top of the water pipes, since the Department considers this the controlling factor rather than the penetration of frost.

The problem of breaks on water mains is universal throughout the United States, modified, of course, by the foregoing condition and by the water pressures maintained on the distribution system. It is true that difficulties have at times been experienced in the case of work which has required exceptional speed in construction in order to maintain uninterrupted water service, but such cases are rare. The Gas Company is experiencing similar difficulties on their sub-surface structures. The breaks experienced by the Water Department are on mains of all sizes, and considering the extent of the system (which comprises approximately 1,450 miles of pipes from 6 inches to 60 inches in diameter) the number is certainly not unusual.

We are endeavoring to meet the new conditions of traffic and failures of water mains by improving the quality of pipe and by the use of reinforced concrete and steel pipe protected by a coating for the larger distribution mains, and by the location of valves at closer intervals. Cast-iron pipe, however, is favored on account of its remarkable durability and long life.

We consider it significant that coincident with the increase in the number of water main failures, efforts are being made by highways and roads engineers to prevent deterioration of roadway sub-surfaces by controlling the excessive loading of motor trucks, for the motor truck has brought about new traffic conditions, which are showing their effect not only upon the highway structures themselves, but upon sub-surface structures as well.

The above article appeared in the Baltimore Municipal Journal, the official publication of that city.

Operating Sewage Treatment Plants

At the sixth of the annual conferences on sewage treatment held under the auspices of the Engineering Extension Department of Iowa State College, Prof. Earle L. Waterman read a paper entitled "The Small Sewage Treatment Plant" in which he gave some excellent suggestions to operators of such plants. Said he: "The operator must first learn just what each unit of his plant is to do and what must be done to keep it in successful operation. This information should be given to him by the engineer who designed the plant.

"One of the best examples of this phase of the engineer's work is the very complete set of operating instructions which was given to the operator of the sewage-treatment plant at the State Hospital at Woodward, Iowa. This plant consists of an Imhoff tank, dosing chamber and sand filters. An isometric drawing was made which shows clearly the different parts of the Imhoff tank. This drawing, together with three typewritten instruction sheets, was posted at the plant. Forms were also provided for recording the operating details of the Imhoff tank and the filters. Such information, together with verbal instructions, outlines the policy of such a factory and provides for a record of the results obtained.

"Actual records of plant operation are just as important for a small plant as for a large one. They enable the operator to build up a history of what the plant has accomplished under varying conditions, and make it possible for him to operate the plant more intelligently. Intelligent operation is usually efficient operation. The records required at the small plant mentioned above were the daily records of the volume of sewage flow, the weekly records of the depth of sludge in the sludge compartment of the Imhoff tank, the result of the weekly test of the sedimentation attained in the tank, and the methylene-blue test of the stability of the effluent from the filters. In addition to these definite daily and weekly records, other pertinent facts, such as weather, temperature, drawing of sludge, removal of sludge from the drying

bed, raking of filter surface, and scraping of filter surface should be recorded under the appropriate date. The careful keeping of such records will result in improved plant operation.

"Many operators of small sewage-treatment plants are not as fortunate as the operator at the Woodward plant, for they are in the position of the man who has to learn to operate an automobile without having an instructor to teach him or an instruction book to guide him. In such a case the first thing to do is to get all the information possible concerning the plant. This information may be obtained from engineers in the service of the State Department of Health or from competent sanitary engineers who design sewage-treatment plants. Conferences, such as are held annually at Ames, provide an excellent opportunity for the operators of small treatment plants to acquire helpful information.

"There is another phase of the operation of sewage-treatment plants which deserves more attention than it usually receives. This is the general appearance of the plant. Does your plant look as though someone was interested in it, or does it have the appearance of neglected property? Are you glad to show your factory to visitors, or is the place avoided because it is dirty and generally uninviting in appearance? If the factory is shunned almost as much as a house which has a smallpox placard on it, how can you expect to obtain the public interest and the support which is necessary for efficient operation and maintenance?

"Very little care is needed to keep the plant clean. Some extra effort is required to keep the grass trimmed, to provide walks, to set out a few trees and shrubs and possibly some flowers. Yet the results are well worth the effort. The sludge from the tanks is an excellent fertilizer, and its use will make the growing of grass, flowers, shrubs and trees very easy. If the sewage-treatment plant is a place which is interesting and attractive, more of your fellow citizens will visit it and share your pride in it. The result will be better public support and better plant operation."

The operating instructions referred to are as follows:

Operating Schedule for the Sewage-Treatment Plant at the State Hospital, Woodward, Iowa

DAILY

1. Visit the plant.
2. Give every part of the plant careful inspection.
3. Record the amount of sewage flow.
4. Fill out the report blank for the day.

WEEKLY

1. Take samples of raw sewage and of tank effluent in the Imhoff conical glasses, and find the per cent removal of solids after 2 hours settling. It should average 95 per cent.
2. Break up the scum in the gas vents with the hose.
3. Measure and record the depth of sludge in the sludge chamber.
4. Clean the inflow channels and the inlet and outlet weirs.
5. Skim the sedimentation chamber.
6. Squegee the side walls, aprons and slot. (This may have to be done more, or less, frequently.)
7. Take a sample of the filter effluent for the methylene blue test for relative stability. When kept at a temperature of 68° F., the blue color should be retained for at least 10 days.
8. Operate all valves.
9. Turn water through the sludge grids for one minute.
10. Fill out the report blank to date.

NEVER

1. Never fill the tank with sewage when empty. Use water.
2. Never unnecessarily agitate the contents of the sedimentation chamber.
3. Never by-pass sewage either at the inlet or from the siphon chamber without recording the reason, date and duration, and notifying the State Board of Health within 24 hours.
4. Never run out large amounts of sludge at a time; better, small amounts every two to six weeks.
5. Never withdraw all the ripened sludge. Some should be left to seed the tank.
6. Never fill the sludge bed to a depth of more than 18 inches.
7. Never allow the sludge in the sludge chamber to rise closer to the slot than 2 feet.
8. Never stir the surface of the sand filters to a depth greater than ½ inch.
9. Never allow the filter beds to stand flooded.
10. Never by-pass sewage directly to the underdrains by digging holes through the sand.
11. Never allow weeds and grass to clog the surface of the filters.
12. Never add new sand which has not been approved by the State Board of Health.

ALWAYS

1. Always recollect that the business of this plant is to transform the organic matter in the sewage so that the final filter effluent will be clear and non-putrescible.
2. Always keep in mind that only about 1/3 of the total organic matter settles out in the Imhoff tank.
3. Always remember that the remaining 2/3 must be oxidized by bacterial action in the filter beds into harmless mineral compounds.
4. Always back-fill the sludge pipe with water, and flush out the pipe running to the sludge bed, after withdrawing sludge.
5. Always clean the surface of the sludge bed before applying a new dose, and add more top sand if necessary.
6. Always make sure that there is enough room in the sludge chamber for the winter sludge.
7. Always note the distribution of sewage over the filters, and if uneven, correct it by re-leveling the beds or re-baffling the distributors.
8. Always keep the filter surface open by raking or harrowing to a depth not greater than ½ inch. When this fails to prevent ponding, remove the upper ⅛ inch of sand and surface mat. Not more than 1 inch of sand should be removed in one year.
9. Always give the beds a thorough overhauling in the late fall just before freezing weather. Pile up the dirty sand in small piles 6 to 8 inches high and 3 to 6 feet apart. These piles will help support the ice.
10. Always watch for warm days in winter, when the surface of the filters may be put into good condition.

Installing Cross in 36-Inch Main

The city of Waterbury, Conn., found it necessary to connect to its 36-inch cast iron supply main two lines for an important residential section at a point where no T or cross has been laid in the supply main. As this was one of the city's most important mains, it was necessary that the installing of the cross be completed as quickly

as possible. The street was opened during the day and pumps brought alongside the opening for removing water that would drain from the pipe when it should be opened. Flange and bell specials for connecting the flanged cross to the 36-inch pipe were on hand and at 10 P. M. water was shut off from this section of the main and work was begun with an oxy-acetylene torch. A number of holes were first cut in the bottom of the pipe through which the water was drained. which water was immediately removed from the trench by the pumps. The bell was then cut off by the torch around about two-thirds the circumference of the pipe, following which the length of pipe was readily lifted from position and the cross and specials previously obtained were installed in place. The superintendent considered that the use of the torch for this purpose would occupy much less time than drilling a series of holes, cutting, or any other practical method.

California Highway Devices

Many devices for facilitating highway construction and repair have been perfected by employes of the California Highway Commission

By Charles W. Geiger

Many devices and special pieces of equipment have been perfected and built by various employes of the California Highway Commission which are rendering valuable service by facilitating the construction and repair of highways throughout the state of California.

Maintenance men in Division V have been endeavoring to work out a plan for a hot blast to clean out and dry cracks that are to be filled and patched. A hose attached to the exhaust of a motor truck was used but the plan was not fully successful. It is planned to repeat the experiment making a direct connection, eliminating the muffler.

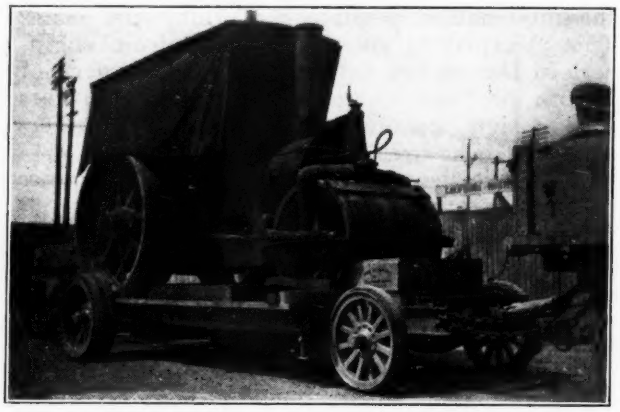
The Fruitvale shops of the Highway Commission have constructed a number of 165-gallon oil heating and spreading units, mounted on trailers and equipped with an underslung heating chamber capable of taking 110-gallon drums. The initial heating of the oil will take place in the drums, from which it will be pumped to the Georges patcher kettles for final heating. Force pumps and spray nozzles are used for spreading the oil during patching operations.

A very useful piece of equipment in service in Division VIII is a rubber-tired trailer on which is mounted a large water tank for hauling water over long distances in the desert.

Besides equipment for moving head walls in connection with lengthening of culverts, an interesting piece of equipment turned out at the Lankershim shops (Division VII) is a 14-S Lakewood mixer mounted on a heavy aviation chassis, making a paver with rubber tires, capable of being towed behind a truck at full speed.

Considerable notable work has been turned out by the Fresno Shops (Division VI) in the past, including the construction of a heavy duty trailer from spare parts. This trailer is low, can carry eight tons, and does away with the need of a loading platform.

A special feature of the equipment of service in Division I is the completely equipped one-ton



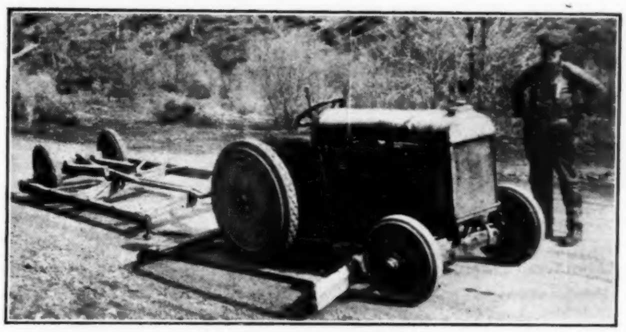
TRAILER BUILT AT FRESNO SHOPS OF CALIFORNIA HIGHWAY COMMISSION.

service truck which, in effect, moves the shop to the job. Equipment of the same make is kept on the same job, parts being interchangeable, and repairs thus facilitated.

A laboratory chemical engineer in the employ of the Highway Commission has turned out a new material for filling piston scores, which, in many cases, may make the reboring of scored cylinders unnecessary. The saving resulting to the Central Repair Shops at Sacramento should be considerable from this one detail worked out by the laboratory, if it proves the success now indicated.

The Central Repair Shops constructed a drag of Ford wheels and an old automobile frame which may be moved at high speed from one job to another and quickly dropped in place for instant use. This is accomplished by means of a specially constructed axle and pipe. The drag is used to keep the highway smooth in the Sacramento Canyon of the Pacific Highway. These shops also built a number of dump cars mounted on Ford wheels which are used for moving small slides on mountain roads to places where material is needed for shoulders and embankments.

A one-man pavement marker mounted on a motorcycle sidecar frame was built at one of the division shops of the Highway Commission which is used to paint guide lines in the center of the pavement, on bridges, curves and at other places where they may add to the safety of traffic. The apparatus consists of a marker wheel with a felt tire hung on an eccentric axle with a lever attached by which it may be raised or lowered from the pavement; a fifteen-gallon asphalt or paint container with a feeder pipe and a valve to the wheel; and a fifteen-gallon sand container



DRAG BUILT OF FORDSON WHEELS AND OLD AUTO FRAME.

with a spreader pipe at the rear of the marker wheel. The asphalt feed pipe valve and the sand feed pipe valve are both operated by the same lever. The operator has but two motions to perform, lower the marker wheel, and turn on the asphalt and sand. A collapsible rod extends to the edge of the pavement to keep the wheel in the center of the highway. A low gear engine sprocket makes it possible to operate the machine at a speed as low as 2½ miles an hour. The cost of operation, including labor, equipment rental, and materials, does not exceed 40 cents a mile.

Paving Brick Standards

Reference was made last month to the actual use being made of the several standard sizes of paving brick. Since that item was written the Permanent Committee dealing with the subject met in Washington and eliminated the 3x3½x8½ wire cut lug brick, which represented only 2 per cent of the total shipments in 1924.

The other four standards made 82.1 per cent of the year's shipments, leaving about 16 per cent divided among the special or non-standard sizes.

The most marked growth of any special variety outside of the recognized list was that of the 2½"x4"x8½" vertical fibre (plain wire cut) brick. This size and type of brick increased from 2.2 per cent of total shipments in 1922 to 4.4 per cent of shipments in 1924. Reports from manufacturers indicated a decided trend toward a thinner brick for paving streets and highways of light or medium traffic.

It was the judgment of the committee that the year 1925 would in all probability determine the value of this thinner brick and that including it in the list of recognized types and sizes could be given careful consideration at the next meeting of the committee in 1926.

Street Paving in 1924

Tabulation of information received, subsequent to that appearing in the February issue, from about one hundred additional cities

SHEET ASPHALT AND ASPHALT CONCRETE LAID IN 1924

City and State.	Sheet Asphalt Amount Sq. yd. or mi.	Sheet Asphalt Cost.	Asphalt Concrete Amount Sq. yd. or mi.	Asphalt Concrete Cost.
Alabama:				
Albany	....	....	48,500	$100,880d
Decatur	....	....	94,000	211,500d
Huntsville	....	....	2	105,000n
Arizona:				
Tucson	....	....	16,804	55,540o
California:				
Corina	....	....	61,512	1.35m
Fresno	....	....	60,090	196,560o
Long Beach	1.3	$141,781	2.8	172,139
Los Angeles	186,022	561,142d	88,834	230,360d
Ontario	....	....	63,740	98,200
San Bernardino	....	....	3,645	....
San Francisco	54	137e	219,232	575,223e
Colorado:				
Colden	....	....	72,900	....
Connecticut:				
New Britain	....	....	8,966	24,579r
New Haven	126,000	220,600	....	....
Waterbury	29,936	26,696	....	....
Delaware:				
Wilmington	52,400	3.48ms	....	....
Illinois:				
Joliet	....	....	45,400	216,500t
Quincy	68,627	181,700a	....	....
Kansas:				
Topeka	....	....	49,500	2.48dm
Louisiana:				
New Orleans	1,740	6,415e	9,790	30,214e
Maryland:				
Hagerstown	10,200	65,000a	....	....
Massachusetts:				
Boston	19,217	....	....	....
Brookline	8,065	30,085e	....	....
Michigan:				
Detroit	1,249,375	5,961,886e	....	....
Minnesota:				
Duluth	18,951	104,928a	....	....
St. Paul	171,226	539,362	160,056v	497,774
			16,598w	46,142x
Mississippi:				
Biloxi	40,000	200,000a	12,000	20,000a
Missouri:				
Carthage	....	....	2,628	3,416
Kansas City	2,581	12,556	....	....
Nebraska:				
North Platte	52,000	130,000i	....	....
Nevada:				
Reno	....	....	87,778	135,590e
New Jersey:				
Orange	7,410	2.35rm	765	203r
Plainfield	37,000	115,070f	1,970	3,250f
Trenton	95,535	305,969e	....	....
Westfield	14,417	22,102c	....	....
New York:				
Manhattan	169,855	....	10,302	....
Ohio:				
Barberton	....	....	7,174	24,563f
Lakewood	7,095	22,190d	39,260	234,665g
Pennsylvania:				
Philadelphia	6.94j	570,300e	....	....
	20.2	1,440,000y	....	....
South Carolina:				
Union	25,638	28,512c	....	....
Tennessee:				
Knoxville	800	3,200k	67,315	332,208k
Virginia:				
Charlottesville	5,353	11,864b	45,500	126,311b
Washington:				
Seattle	2,945	....	....	....
Spokane	....	....	7,532	13,160d
Wisconsin:				
Milwaukee	32,900	91,674	35,400	102,248
Oshkosh	....	....	19,802	58,869a

a—Entire pavement. b—Entire improvement. c—Wearing surface only. d—Surface and base. e—Surface, base and grading. f—Surface, base, grading and curb. g—Surface, base and curb. i—Surface, base, grading, curb and 5% engineering. j—Resurfacing on old base. k—Surface, base, grading, curb, storm sewers and sanitary sewer laterals. m—Per square yard. n—Includes concrete base, common excavation, curb and gutter, sewers and watermains. o—Surface, base, grading, sidewalk, curb and gutter. r—Paving, grading, inspection and engineering. s—Surface, base, grading, resetting curb and paving back of curb. t—Includes engineering. v—3-in. pavement on concrete base. w—2-in. pavement on concrete base. x—Everything except curb. y—Removing existing wearing surface and old base, surface, base and grading.

ROCK ASPHALT AND BITUMINOUS MACADAM LAID IN 1924

City and State	Rock Asphalt Amount Sq. yd. or mi.	Rock Asphalt Cost	Bituminous Mac. A-asphalt. T-tar Sq. yd. or mi.	Bituminous Mac. Cost
California:				
Ontario	....	....	22,000A	$11,000
Pittsburg	....	....	7,445T	15,446
Redwood City	....	....	8,000A	0.15m
San Bernardino	....	....	558,000A	....
Connecticut:				
New Haven	....	....	2,500A	4,500
Illinois:				
Joliet	....	....	4,600A	10,000
Louisiana:				
New Orleans	21,160	73,254e	....	....
Maryland:				
Hagerstown	....	....	2,200A	2,500b
			25,315T	27,896b
Massachusetts:				
Boston	....	....	42,415A	....
Brockton	....	....	10,100A	18,000b
Brookline	....	....	26,858T	....
Dartmouth	....	....	5,360A	8,991e
			32,060T	32,600e
Grafton	....	....	¼ mi.A	18,000
Minnesota:				
Mankato	....	....	791T	1,891
St. Paul	....	....	2,717A	3,559e
Missouri:				
Boonville	....	....	1,000T	1,500
Kansas City	....	....	131,609A	307,141
New Jersey:				
Orange	....	....	2,935A	3,522c
			14,778Aj	0.85m
			3,154T	3,786c
New Jersey (Continued)				
Plainfield	....	....	9,310T	26,321f
Roselle Park	....	....	450T	626n
Westfield	....	....	29,145T	52,000s
North Carolina:				
Wilmington	4,800	14,688	....	....
Ohio:				
Barberton	8,843	33,902f	....	....
Pennsylvania:				
Bradford	....	....	4,000T	....
Lansford	1,200	2,880e	....	....
Norristown	....	....	16,273T	18,664r
Philadelphia	....	....	6.66A	195,000e
Rhode Island:				
Pawtucket	....	....	39,000A	....
Texas:				
Mineral Wells	....	....	6,000A	1,800
Wisconsin:				
Milwaukee	....	....	277,400T	192,500
Oshkosh	....	....	2,994A	6,138

b—Entire improvement. c—Surface only. e—Surface, base and grading. f—Surface, base, grading and curb. j—Resurfacing on old base. m—Per square yd. n—Pavement, excavation and underdrains. s—Surface and grading. v—Includes excavating old macadam.

OTHER BITUMINOUS PAVEMENTS

City and State	Kind of Pavement	Amount	Cost
Arizona:			
Tucson	War.-Bit.	118,579	$383,633o
	Coarse Willite	11,133	36,030o
California:			
Long Beach	Willite	.6 mi.	37,882
Los Angeles	War-Bit.	127,400	425,950d
Santa Monica	War-Bit.	472,223	85,000
Louisiana:			
New Orleans	War-Bit.	63,830	234,269e
Massachusetts:			
Boston	War-Bit.	110,552	....
Brookline	War-Bit.	21,431	55,499e
Montana:			
Missoula	War-Bit.	9,800	....
New Jersey:			
Orange	War-Bit.	12,902	32,386e
		4,177j	14,580e
New York:			
Manhattan Boro.	Asphalt block	1,542	....
Oklahoma:			
Okmulgee	Willite	61,000j	251,000b
Pennsylvania:			
Norristown	Amiesite	4,817	4,386v
Tennessee:			
Knoxville	Willite	1,200	1,200k
Texas:			
Waco	War-Bit.	47,900	3.10md
Utah:			
Salt Lake City	War-Bit.	15,474	35,690d
Wisconsin:			
Antigo	War-Bit.	50,700	160,110h

b—Entire improvement. d—Surface and base. e—Surface, base and grading. h—Surface, base, grading, curb and gutter. j—Resurfacing on old base. k—Surface, base, grading, curb, storm sewers and sanitary sewer laterals. m—Per square yard. o—Surface, base, grading, sidewalk, curb and gutter. v—Includes excavating old macadam

OTHER NON-BITUMINOUS PAVEMENTS

City and State	Kind of Pavement	Amount Sq. yd. or mi.	Cost
Connecticut:			
New Haven	Creosoted wood blk.	1,200	$8,500
Maryland:			
Hagerstown	....	4,000	3,200
Massachusetts:			
Boston	Creosoted wood blk.	3,911	....
Minnesota:			
St. Paul	Creosoted wood blk.	13,005	59,823
New York:			
Manhattan Boro.	Creosoted wood blk.	656	....
Pennsylvania:			
Easton	Kentucky rock	833	1,020
Philadelphia	Redressed gran. blk.	9.2	440,600e
Scottdale	Slag	3,260	3,800
Utah:			
Salt Lake City	Pea gravel	21.1	....
Washington:			
Seattle	Creosoted wood blk.	12	....

e—Surface, base and grading.

WATERBOUND MACADAM AND GRAVEL

City and State	Waterbound Macadam Amount Sq. yd. or mi.	Waterbound Macadam Cost	Gravel Amount Sq. yd. or mi.	Gravel Cost
Alabama:				
Huntsville	....	....	1 mi.	....
California:				
Oxnard	....	....	40,000	....
San Francisco	1,200	$600d	....	....
Connecticut:				
New Britain	7,275	11,400r	....	....
Iowa:				
Boone	....	....	11,646n	$15,400
Kansas:				
Emporia	....	....	9,000	8,000e
Maine:				
Bangor	....	....	1 mi.	5,000
Massachusetts:				
Dartmouth	....	....	6,900	1,960e
Minnesota:				
Duluth	....	....	10,338	35,636
Mankato	3,580	4,165	....	....
Stillwater	....	....	1,810t	3,950
Missouri:				
Maplewood	7,456	12,320	....	....
Mississippi Co.	....	....	21,000	32,000
St. Charles	6½	27,473	....	....
New Jersey:				
Vineland	....	....	2	....
Oregon:				
Corvallis	13,000	....	2	....
Pennsylvania:				
Easton	2,100	1,537	....	....
Rhode Island:				
Pawtucket	....	....	3,360	....
Tennessee:				
Knoxville	230,000	149,000k	....	....
Texas:				
Mineral Wells	6,000	4,500	....	....
Waco	....	....	15	....
Utah:				
Salt Lake City	....	....	43	....
Virginia:				
Fredericksburg	....	....	16,860	....
Washington:				
Chehalis	....	....	3,084	1,464c

a—Surface only. d—Surface and base. e—Surface, base and grading. k—Surface, base, grading, curb, storm sewer and sanitary sewer laterals. n—Cubic yards. r—Grading, paving, inspection and engineering. t—Loads.

STONE BLOCK AND BRICK PAVEMENTS

City and State	Stone Block Amount Sq. yd.-mi.	Stone Block Cost	Brick Amount Sq. yd.-mi.	Brick Cost
California:				
San Francisco	....	....	223	$1,200d
Connecticut:				
New Haven	2,100	$7,500	....	....
Delaware:				
Wilmington	5,650	4.16ms	5,550	5.44ms
Illinois:				
Alton	....	....	41,746	122,594d
Kankakee	....	....	5,000	5.15m
Mt. Vernon	....	....	13,000	56,000h

STONE BLOCK AND BRICK—Continued

City and State	Stone Block Amount Sq. yd.-mi.	Stone Block Cost	Brick Amount Sq. yd.-mi.	Brick Cost
Kansas:				
Emporia	....	....	25,963	115,576f
Independence	....	....	10,500	43,800
Topeka	....	....	4,500	3.90dm
Louisiana:				
New Orleans	....	....	43,630	100,643e
Massachusetts:				
Boston	117,994	....	1,585	....
Minnesota:				
St. Paul	....	....	144,444	579,220e
South St. Paul	....	....	5,326	24,227b
Mississippi:				
Biloxi	....	....	20,000	70,000a
Missouri:				
Kansas City	....	....	1,937	7,631
New Jersey:				
Orange	316.6	665n	....	....
	600.6	3,574	....	....
Trenton	24,900	126,682e	4,590	22,978e
New York:				
Manhattan Boro.	174,221	....	....	....
Tarrytown	....	....	700	....
Ohio:				
Lorain	....	....	5,545	20,700a
Pennsylvania:				
Bradford	....	....	8,133	55,500b
Lansford	....	....	3,600	30,000e
Midland	....	....	5,183	36,709f
Philadelphia	0.045	6,500	0.27	21,800e
	11.1n	927,600e	....	....
Pittston	....	....	47,420	225,609e
Rhode Island:				
Pawtucket	8,000	7.00mt	....	....
Washington:				
Seattle	12	....	8,113	....
Wisconsin:				
Milwaukee	9,200	56,873	1,400	7,400

a—Entire pavement. b—Entire improvement. d—Surface and base. e—Surface, base and grading. f—Paving, grading and curb. h—Surface, base, grading, curb and drainage. m—Price per square yard. n—Reclipped block. s—Surface, base, grading, resetting curb and paving back of curb. t—Grading, base and 6 in. standard block.

CONCRETE PAVEMENT LAID IN 1924

City and State	Reinforced Concrete Amount Sq. yds. or mi.	Reinforced Concrete Cost	Rein. Wt. per 100 sq. ft.	Not Reinforced Amount Sq. yds. or mi.	Not Reinforced Cost
California:					
Long Beach	....	....	....	9.0	$580,395
Los Angeles	....	....	....	1,145,213	3,228,631c
Manhattan Beach	....	....	....	9,781	79,200a
Orange	....	....	....	72,889	131,214e
Palo Alto	....	....	....	105,197	196,503g
Pittsburg	....	....	....	10,445	25,000
San Bernardino	....	....	....	205,889	....
San Francisco	....	....	....	54,107	152,886e
Connecticut:					
New Britain	4,305	$17,651a	34	....	....
New Haven	....	....	....	35,000	90,000
Georgia:					
Macon	....	....	....	20,796	50,776c
Illinois:					
Centralia	52,000	2.50m	....	....	....
Herrin	14,000	60,000	35	....	....
Joliet	650	3,000	....	600	2,600
Kankakee	53,000	2.55m	....	....	....
Mt. Vernon	20,000	80,000h	42	....	....
Quincy	....	....	....	16,422	49,057h
Sycamore & De Kalb.	....	....	....	8,337	32,000w
Kansas:					
Independence	....	....	....	3,000	6,400
Topeka	....	....	....	22,000	1.85md
Maine:					
Bangor	8,947	24,000e	85	....	....
Maryland:					
Hagerstown	....	....	....	3,000	6,000b
Massachusetts:					
Boston	46,655	....	....	4,500	....
Grafton	1½	60,000	....	....	....
Michigan:					
Coldwater	8,300	28,000	....	....	....
Minnesota:					
Albert Lea	....	....	....	500	1,200
Duluth	72,841	359,917a	....	....	....
Mankato	....	....	....	1,578	3,001
St. Paul	162,957	381,549x	....	12,430	31,310x
South St. Paul	2,000	5,000b	35	....	....
Missouri:					
Boonville	....	....	....	18,000	40,000
Cape Girardeau	....	....	....	3	225,000
Carthage	....	....	....	17,752	40,735
Hannibal	99,243	306,583f	35.7	....	....
Independence	....	....	....	22,000	58,000
Kansas City	....	....	....	214,632	563,374
Liberty	....	....	....	5,545	15,416
Maplewood	39,898	104,828g	48.8	....	....
Mississippi	7,000	23,000c	....	....	....
Nebraska:					
North Platte	....	....	....	4,000	14,800i
New Jersey:					
Orange	3,102	9,244	65	....	....
Roselle Park	15,586	55,954n	67	....	....
Trenton	7,173	17,742e	40	....	....
Vineland	52,055	230,000z	56	....	....
Westfield	9,528	38,858e	....	....	....
New Mexico:					
Santa Fe	14,881	36,160	....	....	....
New York:					
Ithaca	19,000	60,000e	44	....	....
Oswego	2,939	7,192c	....	....	....
Ohio:					
Huron	8,000	30,000f	....	....	....
Lakewood	1,678	8,247g	41	....	....
Lorain	48,200	192,800a	50	....	....
Oklahoma:					
Ardmore	....	....	....	7,537	26,081
Okmulgee	....	....	....	3,125	14,306b
Oregon:					
Corvallis	....	....	....	30,000	....
Pennsylvania:					
Bradford	....	....	....	483	....
Easton	29,964	96,330	65	....	....
Northampton	9,820	42,352	....	....	....
Palmerton	3,148	18,027r	....	....	....
Tennessee:					
Knoxville	....	....	....	1,100	3,400o
Texas:					
Palestine	7,000	19,000c	....	....	....
Utah:					
Salt Lake City	....	....	....	3,585	8,604c
Washington:					
Chehalis	....	....	....	34,394	76,966
Everett	....	....	....	43,245	125,416b
Seattle	200	....	....	572,136	2,224,493
Spokane	....	....	....	534	984c
Wisconsin:					
Milwaukee	....	....	....	24,040	66,000
Oshkosh	24,475	79,371e	....	633	1,520e
Puyallup	....	....	....	12,038	40,248
Racine	63,107	182,379	40	....	....

a—Entire pavement. b—Entire improvement. c—Concrete only. e—Pavement and grading. f—Pavement, grading and curb. g—Pavement and curb. h—Pavement, curb, drainage and grading. i—Pavement, grading, curb and 5% engineering. k—Grading, curb, resetting manhole tops. m—Price per square yard. n—Paving, grading and underdrains. o—Pavement, grading, curb, storm sewers, sanitary sewer laterals. r—Grading, cast-iron pipe, inlets. w—Grading, drainage, inlets, sidewalk, curb and gutter. x—All except curb. z—Paving, grading, drainage, curb and gutter.

CEMENT SIDEWALKS LAID IN 1924

City & State	Amount Sq. ft. or mi.	Cost
Arizona:		
Tucson	1,516,536	$420,020
California:		
Corena	7,650	......
Long Beach	39	226,000
Los Angeles	7,992,450	1,711,890
Manhattan Bch.	1,818	5,000
Orange	10,000	1,500
Orland	5,000	750
Palo Alto	12,348k	10,000a
San Bernardino	450,000	404,500
Santa Monica	300,000	60,000
Connecticut:		
Waterbury	53,649	18,897
Illinois:		
Alton	14,000k	14,000
Collinsville	5	0.25b
Granite City	166,000	0.22½b
Joliet	12,000	0.27b
Mt. Vernon	7	......
Quincy	100,000	20,000
Iowa:		
Boone	110,000	5,000
Kansas:		
Independence	4,000	600
Topeka	50,000	0.18b
Louisiana:		
New Orleans	29,280	......
Maine:		
Bangor	4,500	1,500
Massachusetts:		
Boston	821,817	......
Brockton	6,300	1,600
Minnesota:		
Albert Lea	26,442	3,989
Duluth	367,409	8,842
Mankato	7,000	840
St. Paul	736,824	114,207
South St. Paul	12,000	1,680
Stillwater	19,533	2,735
Mississippi:		
Vicksburg	2	......
Missouri:		
Cape Girardeau	1	5,300
Independence	22,000k	4,500
St. Charles	2,500k	2,750
Montana:		
Livingston	60,000	0.20b
Nevada:		
Reno	60,000	9,900
New Jersey:		
Trenton	22,149	5,751
Vineland	18,000	......
Westfield	9,070k	9,922
New York:		
Ithaca	15,000	3,000
Tarrytown	600	......
Ohio:		
Lorain	15,000	3,500
Oklahoma:		
Altus	1,000	......
Oregon:		
Corvallis	2	......
Pennsylvania:		
Lansford	16,000	10,000
Shippenburg	5,120	700
Rhode Island:		
Pawtucket	77,508	2.90c
South Carolina:		
Union	56,725	8,508
Tennessee:		
Knoxville	4	......
Texas:		
Palestine	4,500	1,300
Utah:		
Salt Lake City	53,850	......
Vermont:		
Bennington	22,500	5,000
Virginia:		
Fredericksburg	567	......
Washington:		
Chehalis	218,343	37,234
Everett	27,387	......
Seattle	971,100	195,000
Spokane	128,430	15,700
Wisconsin:		
Milwaukee	930,000	0.25b
Oshkosh	3	......

a—Includes curb. b—Per square foot. c—Per square yard. k—Lineal feet.

Calumet Reservoir and Tunnel

Twenty-four-inch water main carried under river in seven-foot tunnel, excavated with pneumatic shovels. Constructing two-million gallon circular reservoir of reinforced concrete

By Ernest A. Clark, C. E. *

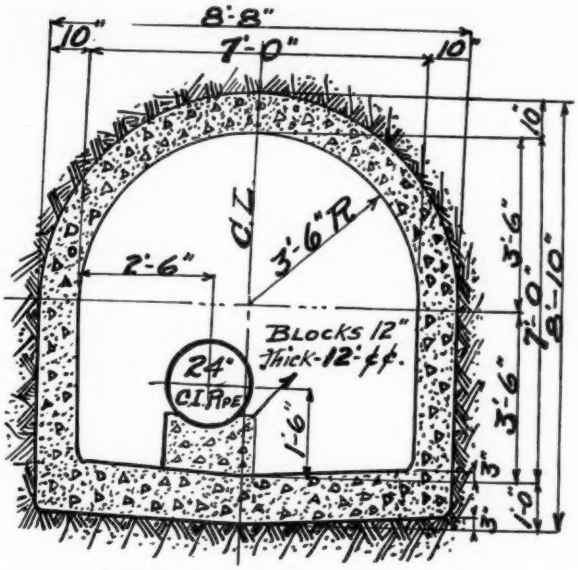
Of the 838,000,000 gallons of water pumped daily from the lake by Chicago, 17,500,000 gallons is sold by that city to thirty-three suburbs located around it. A large part of this water is delivered between 1 A.M. and 5 A.M., when the demand of the city is least, and is stored by the several communities for use during the day. The latest city to join this list is Calumet, Ill., formerly West Hammond. This city has signed a contract calling for 2,000,000 gallons per day from the Chicago Water Department, for which it is to pay 62½ cents per thousand cubic feet. The water received by Calumet betwen 1 and 5 A.M. will be stored in a 2,000,000-gallon reinforced-concrete reservoir and pumped from there into the city mains as required. The water will be pumped from Chicago through a 24-inch cast-iron main laid through and supplying Colehour, Ford City, Hegewisch and Burnham, and passing under the Grand Calumet river as a siphon laid in a tunnel.

SHOWING LOCATION OF SHAFTS FOR PIPE SIPHON TUNNEL UNDER GRAND CALUMET RIVER.

SIPHON TUNNEL

To provide for dredging in the Calumet river, it was necessary to carry the pipe through a tunnel, the section of which was made large enough for future gas lines and telephone and light cables. The top is a semi-circular arch with 3-foot 6-inch radius suported by vertical side walls 3 feet 3 inches high, the floor sloping 3 inches each way toward the center; all inside dimensions. The concrete is 10 inches thick in walls and arch and 12 inches thick in the bottom. The tunnel slopes 6 inches to a sump at the south end to provide drainage. The length is 263 feet from center to center of the two end shafts, which provides for a 250-foot river channel. Nearly all of the excavated mate-

*President Subway Engineering Company.



CROSS-SECTION OF TUNNEL UNDER CALUMET RIVER.

rial was taken out of the south shaft and will be used for fill in an adjacent park.

Each of the shafts is 10 feet diameter and 60 feet deep, with 18-inch walls reinforced with ½-inch rods 24 inches apart in each direction. In the south shaft the excavated material for the first 15 feet was fine water-bearing sand with a few layers of shells and gravel, the balance of the excavation being clay; in the north shaft excavation was through black muck for about 15 feet followed by clay with a layer of gravel and shells between. Small boulders and small pieces of slate were found in the clay, which got harder and tougher as the shafts were deepened.

Open digging was used in the south shaft to the top of the tunnel and then underpinning from there to the bottom. Little water was found at 35 feet below the surface, although small water-bearing sand pockets were encountered. Below the 45-foot depth the muck was excavated with pneumatic shovels and hoisted in ½-yard tip-over buckets.

In the bottom of the wall lining each shaft was set a cutting edge made by a 4x4x½-inch angle and an 18x¼-inch plate with ⅝x36-inch anchors spaced 24 inches apart. The forms for the shaft concrete were made of wood, there being two 3-foot sections and one 2-foot section for each shaft. They were left in place for 24 hours, and after removal both inside and outside surfaces of the shell were brushed with a 1:2 mortar applied like plaint to fill all small air holes. The concrete shell was constructed upon the ground and allowed to sink for about 40 feet and was underpinned from there to the bottom of the shaft. Thirty days was required for sinking each shaft, the force working consisting of a hoisting engineer and six men.

The equipment for the south shaft consisted of a small Wiley traveling derrick, 11 feet gauge, with a 40-fot boom, and an American 7x10 D.D.D.C. steam hoisting engine with a Dake swinger to handle a ½-yard Kiesler clamshell bucket.

The north shaft equipment consisted of a 2-ton Sasgen stiffleg derrick with a 36-foot boom operated by a 12-horsepower Domestic gas-driven D.D. hoist. As little water was encountered in this shaft, the excavation was done by hand to a depth of 40 feet and then pneumatic shovels were used.

Air for ventilation and for operating the Chicago Pneumatic shovels was supplied by a 10x10 Laidlaw horizontal compressor driven by a 40-horsepower Climax gasoline engine, a 5x6-foot air receiver being used for storage. Concrete for both shafts was mixed in a 7-S gas-driven concrete mixer and was placed in the shaft with a ½-yard Western bottom dump concrete bucket. The water used was piped about 1,000 feet from the city water supply.

TUNNELLING

Of the 250 odd feet of tunnel, 220 feet was mined from the south shaft. The material was a hard, tough clay containing slate and small boulders. An average of 6 feet was mined and concreted during each 9-hour shift. The force for each shift consisted of a hoisting engineer, three pneumatic shovel miners, eight muckers and three top men. Where sand pockets occurred, the tunnel was mined, timbered and concreted in 3-foot sections. The excavated material was handled in the same buckets used for concrete, carried on 14-inch gauge Atlas cars running on a track of 16-pound rails. Carbic lights were used for lighting the tunnel headings.

The forms were made of steel ribs of 6-inch,

INTERIOR VIEW OF TUNNEL, SHOWING FORMS AND MINING WITH PNEUMATIC SHOVELS.

8-pound channels, made in two pieces with angle iron lugs at top and bottom for bolting together, the ends being separated by a 3-inch wood spacing block. The lagging on these steel ribs was made of 2x6 lumber with bevelled edges.

The concrete for both shafts and tunnel was made with gravel, the mixture being 1:2½:4. That for the tunnel was shovelled and tamped into the forms. After 24 hours the forms were removed and the surface brushed with a 1:2 paint-like mortar to fill all small holes.

After the tunnel had been completed, the 24-inch cast-iron pipe was laid in it resting on wood blocks. Then concrete blocks were cast under the pipe at intervals of 8 feet. In the shafts the piping was anchored to 7-inch, 15-pound channels spaced 6 feet apart, ¾-inch U-bolts being used. A 24-inch gate valve was placed in a valve chamber at the top of each shaft. Each shaft roof was provided with a 24-inch manhole frame and cover and a 4x6-foot frame and doors. A steel ladder was built in each shaft reaching from the tunnel floor to the valve chamber. The cost of the tunnel was about $50,000. It was completed in three months.

RESERVOIR

The reservoir is a large, circular, reinforced-concrete tank 180 feet in inside diameter and 13 feet high with a capacity of 2,000,000 gallons. Th floor and roof are 8½ inches thick and the wall 15 inches. The roof and the 3 feet of fill above it are supported by 97 round columns 20 inches in diameter, resting on footings 6 feet square, spaced 16 feet centers. The reservoir was set in an excavation about 6 feet deep. The material was excavated by means of teams and Western slip scrapers, the material being stored around the reservoir and used afterwards for backfill.

The concrete for the reservoir was mixed 1:1-¾:3, 1½-inch washed gravel and washed torpedo sand being used for the coarse and fine aggregates. Five pounds of hydrated lime was added for each bag of cement used. All the concrete was mixed in a 21-S steam driven Ransome concrete mixer.

INTERIOR VIEW OF RESERVOIR, CALUMET CITY.

The reinforced concrete floor slab rests on a sand foundation and was poured in four sections, in the joints between which were set horizontal plates of No. 13 zinc 18 inches wide. Under the wall was placed a footing 3 feet by 1-foot, and under each joint a footing 2 feet wide by 9 inches deep. A sump 7x8-feet, 5 feet deep, was provided for the outlet pipe and a reinforced concrete box 7x8-feet and 5 feet high resting on the floor was constructed for the inlet pipe. Both inlet and outlet pipes were 24-inch cast-iron; each provided with an elbow on the inside of the reservoir wall, the inlet elbow turning up and the outlet elbow down. An 8-inch cast-iron pipe was laid from the bottom of the sump to the sewer in the adjacent street.

Material for the concrete was stored on a plank platform placed on top of the excavated material, and the mixer also was placed there about 13 feet above floor-level. The concrete for the floor was spouted from the mixer to a 1-yard hopper and wheeled from there on temporary runways. The surface of the floor was given a float finish and then covered with sand and kept wet for 10 days.

The circular wall was poured in two sections, with a zinc plate in each vertical joint and similar plates connecting the wall with the floor. The wall forms were made of wood, using 246 uprights spaced 18 inches apart and 1-inch boards. Circular segments were cut on which to rest the uprights and insure the proper curve of the wall. Universal spreader ties were used for wall spacers and ties for holding the forms. After the forms had been removed the spreader holes were filled with 1:2 mortar. Both the inside and outside surfaces of the wall were brushed with 1:2 paint-like mortar and the wall was kept wet for 10 days.

The columns and roof slab were poured from the top, using carts running on a temporary runway resting on the roof form supports. Johnson steel forms were used for the columns. For loading the carts the concrete was elevated with a 24-inchx28-foot portable gas-driven belt conveyor which elevated the concrete to a 1-yard Lakewood hopper resting on the roof form supports. The roof, like the bottom, was poured in four sections with zinc plate joints. The forms for the roof slab rested on 4x4 supports and were built of 4x6 girders and 2x6 stringers with 1-inch floor boards. Four concrete vents were placed in the roof, the inside diameter being 30 inches and the walls 4 inches thick. These vents were 5 feet high and were provided for ventilation, and were covered with a fine mesh bronze screen and capped with a steel hood 5 feet in diameter. A manhole frame with cover was placed in the roof over the outlet pipe. After it had set sufficiently, the roof was covered with 30 inches of sand and 6 inches of black dirt.

Before placing the embankment around the reservoir, it was filed with 4-feet of water to test for leaks in the joint between the floor and the wall. After standing for 48 hours no leaks were found. The reservoir was then disinfected and

the excavated material was embanked against the outside of it, with side slopes of 1:2.

Excavation was started September 15th, 1924, the first concrete was poured on October 13th and the last concrete on November 19th. About 2200 yards of concrete were required, 115 tons of reinforcing steel, 1500 lineal feet of zinc plates for joints, 5,000 yards of excavation, 7,500 yards of backfilling and 1 acre of black dirt and seeding. The cost of the reservoir was about $90,000.

The Subway Engineering Company of Chicago was contractor for the reservoir and siphon tunnel. The Public Construction Company of Hammond, Ind. was contractor for laying the pipe. The Consoer Engineering Company of Chicago was engineer for the work.

Laying Submarine Pipe at San Francisco

Work is continuing on the Hetch Hetchy project for San Francisco, both the water supply and the power plants. City Engineer M. M O'Shaughnessy reported in March that "On or shortly after April 1, 1925, there will be available for delivery at Newark, California, 360,000,000 more or less, kilowatt hours annually of three-phase electric energy to be generated at the Moccasin Creek power house." Work on most features of the project was being pushed and the progress being made seemed to render this possible.

One of the interesting features of recent construction work is the laying of the 60-inch steel pipe across the bay. On this work the Western Pipe & Steel Company has practically completed the installation of the pipe in its contract, including that on the steel bridge structure, except for the last two spans, which are not as yet installed. The Healy-Tibbitts Construction Company has been prosecuting the work vigorously on the construction of the terminal end caisson through which the connection is made between the pipe on the Dumbarton Bridge and the submarine pipe to be laid across the bay. Progress on this work, however, is not up to expectations, the contractor having been delayed on account of difficulties encountered.

At Newark Slough all of the submarine pipe has been placed and dropped from a wooden trestle, by means of screws, into the bottom of the bay. All the lead joints have been poured and calked under working pressure and found to be tight, under a maximum pressure of 170 pounds per square inch.

This disposes of the submarine pipe over the small Newark Slough, about 400 feet in width, and the main portion of the contract near the submarine pipe across Dumbarton Strait is now about to be commenced.

The terminal caisson on the Healy-Tibbitts Construction Company's contract has most of the piles in place. It is very likely that, due to construction difficulties, this work will be delayed two months from the contract date of completion —the first of April.

The contractors have purchased and secured from New York the launchway or cradle used in the construction of the Narrows siphon between Brooklyn and Staten Island. This pipe will be laid from a large barge which will proceed across the bay from west to east, starting at the terminal caisson before mentioned. The first few hundred feet of pipe from the terminal caisson will be laid on a submarine trestle through the soft mud until the grade of the pipe reaches the firm clay. This portion of the pipe is on a curve and will be laid on piling encased with concrete.

TWO MILLION GALLON CALUMET CITY RESERVOIR.
Floor forms. and reinforcement steel for floor and columns in place

The Verdigris River Tunnel

A portion of the Spavinaw Water Supply Project for the City of Tulsa, Oklahoma, which was described in Public Works for January

By W. R. Holway, Chief Engineer

In the January number of Public Works was described the new $7,500,000 water supply for the city of Tulsa, Oklahoma, which involved the building of a conduit 55 miles long. The source of this new supply lies in the Ozark mountains, mostly to the east of Tulsa. The streams in this part of Oklahoma all run north and south, and therefore the conduit was of necessity located across the drainage and not along the course of any stream. This made necessary the crossing of fifteen streams of water large enough to be named, besides two good-sized rivers, the Grand and the Verdigris.

The 800-foot crossing of Grand river with its solid rock bottom by the coffer-dam and open cut method was described in some detail in the recent article mentioned. Most of the smaller streams were crossed by diverting one-half of the flow of the water, laying the pipe, and then turning back the water over the completed half while the remainder was laid. In all of the creeks where excavation could be carried to rock bottom, the pipe was concreted in the rock, and rip-rap placed over the top to prevent scouring by the stream.

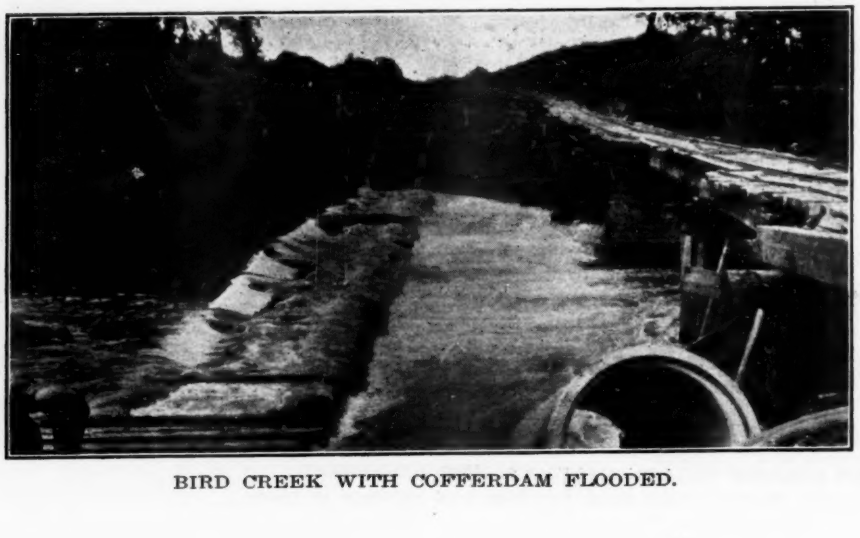
One of the streams of this type is Spavinaw Creek, where the 60-inch concrete pipe was laid in the rock. This crossing was accomplished by working day and night while the Spavinaw Dam was filling. During this period there was only a three-foot pool of water at the crossing and the excavation could be made in a comparatively dry trench by the use of sand bag coffer-dams.

There were three streams, however, where the nature of the river bed made it impossible to excavate to rock, being composed of quicksand on top of stiff clay. Bird creek, fifteen miles east of Tulsa, was of this nature, and the difficulty of this crossing was increased by the fact that this stream was subject to sudden heavy floods, with just as quick receding of the waters. The banks were high and steep, and the soil such that slides were frequent after flood. The cost of this 200-foot crossing—$15,000, exclusive of pipe—is explained by the soil conditions and the fact that it was constructed in an unusually wet season. The method used here was the driving of a sheet-pile coffer-dam, excavation of the top soil, and the driving of timber piling down 30 feet through the quicksand into the stiff clay. The 54-inch concrete pipe was laid on the top of these piles, blocked up along the side with timber, and completely encased between the sheet piling with concrete.

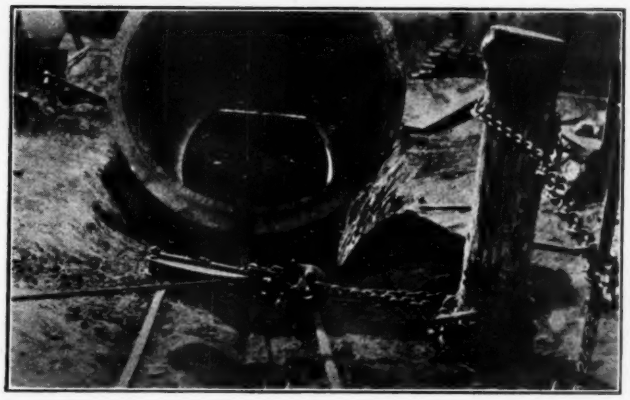
THE VERDIGRIS RIVER AT CROSSING LOCATION.

Verdigris river, twenty miles east of Tulsa, was looked upon as the most difficult stream to cross. At the location of the crossing the river was 250 feet wide and the banks 50 feet high. These banks are composed of silt and black gumbo, and, like those of Bird creek, are subject to frequent slides when saturated with flood waters. A 50-foot flood, rising in a few hours and carrying a tremendous amount of drift, is a common occurrence. Therefore it was decided that the only feasible way of crossing was to tunnel under the river. Drillings in the river bed and on the banks disclosed heavy layers of shale overlying hard, flinty limestone 30 feet under the bed of the river.

Inclines were started from both sides of the river, with an angle of 22½ degrees with the horizontal, from two headings 700 feet apart.



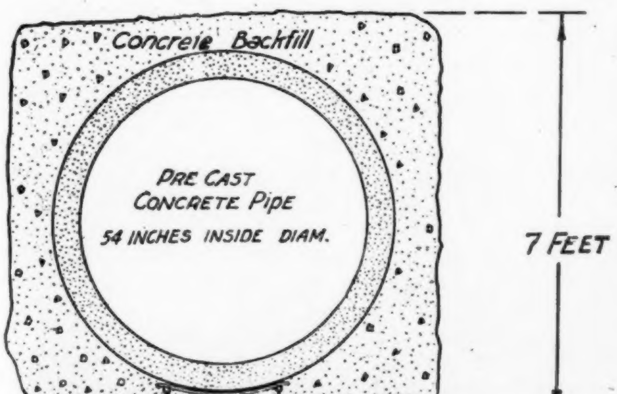
BIRD CREEK WITH COFFERDAM FLOODED.



PIPE ENTERING EAST INCLINE OF TUNNEL ON THE TRUCK ON WHICH IT WAS TRANSPORTED THROUGH THE TUNNEL.

These inclines were heavily timbered through the gumbo and shale until the limestone was reached. As soon as the inclines reached a point 35 feet below the river bed, the tunnel was turned horizontally and carried under the river as an 84-inch bore, roughly circular. Between the shale and the limestone a coal seam 20 inches wide was found, and this coal, of very good quality, was taken out separately and used for fuel under the boilers that ran the hoisting engines. All material taken from the tunnel was put in muck cars which ran on a narrow gauge track through the tunnel. These cars were pulled up the inclines by the hoisting engines. The time required for the excavation of the tunnel was four months.

After the two headings had been holed through and the final muck cleared, the walls and roof were trimmed so that a 12-foot length of 54-inch pipe could pass through the tunnel without hitting. The track was very carefully aligned and ballasted with crushed rock, this ballast serving as a drain during the remainder of the work. Because this was one of the first pieces of work undertaken in connection with the Spavinaw Project, there was no railroad bridge across the river and therefore the pipes for the west incline could not be transported in the usual manner, but were mounted on small trucks constructed to fit the tracks in the tunnel, slid down the east incline, a cable attached, and the hoisting engines pulled them up the west incline and out onto the ground, where they were stored until the remainder of the pipe had been laid.



SECTION OF COMPLETED TUNNEL.

The laying started at the foot of the west incline, continued under the river and up the east incline, after which the pipe that had been pulled through the tunnel was lowered down the west incline and laid from the bottom to the top. Each length was mounted on specially constructed cradles made of steel bars properly bent to fit the rails of the narrow gauge track and to hold the pipe. These trucks and the rails were greased, and each pipe slid down the incline of its own weight, and was pulled into place by the hoisting engine on the other side of the river. Each pipe length weighed approximately seven tons. The process of laying and joining the pipe was extremely difficult and tedious because of the small space in which the work was done and the extreme care with which each pipe had to be aligned with the others. Two or three lengths in a day of 24 hours was all that could be placed, and this part of the work occupied about two months.

Joints between the pipe lengths were made in the same manner as in the remainder of the 55-mile conduit; namely, by calking a wedge-shaped lead gasket from the inside of the pipe into a space left between galvanized steel bell and spigot rings.

The pipe in this tunnel was reinforced for

54-INCH CONCRETE PIPE BEING LOWERED ONTO TRUCK TO BE TAKEN THROUGH VERDIGRIS TUNNEL.

PIPE IN TUNNEL. COAL SEAM AT LEFT BOTTOM.

140-foot head. The reinforcement consisted of two cages, the inner one of triangular wire mesh, and the outside of heavy flat bars welded into rings. The 22½-degree angles were of monolithic construction. An inside form was built flush with the inside of the pipe, and heavy reinforcing steel placed around. The whole space between the inside form and the walls of the tunnel was then filled with concrete. As each length of pipe was laid, the space between the outside of the pipe and the walls of the tunnel was filled with lean concrete.

Two-inch grout pipes were carried along the top of the tunnel and up the inclines; grout was forced into the roof of the tunnel by this means after the concrete backfill had settled. The concrete material was hauled in the dump cars, and placed by shovels. Bulkheads were made of sandbags.

The cost of this crossing, exclusive of the pipe, was approximately $30,000. The tunnel was excavated by the Pitts Bateman Company, sub-contractors under the Walbridge-Aldinger Company of Detroit. The pipe was laid by the Lock Joint Pipe Company of New York, under the personal supervision of their general manager, J. C. Mitchell.

Baltimore Sewer Bids

Bids were received on March 18th by the city of Baltimore, Md., for sewer construction totalling about $90,000, some items of which are of general interest. One of these is the difference between the cost of pipes laid with bituminous joints and with Portland cement joints, respectively. Bids were received on both types of joints from 8 inches to 18 inches diameter. In the case of the 8-inch pipe, four of the five bidders asked 10 cents per foot more for bituminous joint, while the low bidder asked but 3 cents more. For the 10-inch and 12-inch pipe the low bidder asked 5 cents additional per foot and the others 10 cents. For the 18-inch pipe the low bidder asked 10 cents per foot additional and the others from 20 to 40 cents.

Bids were received for excavation and refilling as one item and for furnishing and laying as another. The bids for furnishing and laying vitrified pipe sewer with Portland cement joints were as follows: 27-inch, from $3.60 to $5.25 per lineal foot; 24-inch, from $2.60 to $4.13; 20-inch, from $1.70 to $2.80; 18-inch, from $1.80 to $2.67; 12-inch, from 70 cents to $1.25; 10-inch, from 60 cents to 90 cents; 8-inch, from 42 cents to 50 cents. The 18-inch is double strength pipe and the others standard. For furnishing and laying 6-inch house connections the bids were 30 cents by three of the contracts, and 35 cents and 45 cents by the other two. For furnishing and building 6-inch vitrified pipe standpipes for house connections the low bidder asked 50 cents a foot and each of the others $1.00.

Excavating and refilling for 18-inch to 27-inch sewer was estimated to total 10,450 cubic yards, for which bids ranged from $1.93 to $4.00 per cubic yard. For 8, 10 and 12-inch sewers excavation and backfilling was bid by the lineal foot, the bids varying from $2 to $4 for the 12-inch, from $1.60 to $3.75 for the 10-inch and from $1.40 to $3.50 for the 8-inch. The total of the low bidder was $86,653.80 and that of the high bidder was $119,000.70. The contract was awarded to the low bidder on March 26th.

Dayton Garbage Reduction Plant

Late in 1924 the City of Dayton, Ohio, completed a new garbage reduction plant on the site of a former one, which had been built in 1915 at a cost of $103,000 including a railroad siding. The new plant cost $125,000. The site of the old and new plants is at Whitfield, near Dayton.

In the old plant the process of reduction was to cook the green garbage for about eight hours in the ten digesters, which had a total capacity of about fifty tons. The cooked garbage was pressed in the digesters by steam pressure and then dried in a direct-heat dryer. The dried tankage was degreased by subjection to a gasoline bath in a percolator. The grease was drawn off and sold for soap-making purposes, and the tankage prepared for the market as a fertilizer.

The average net cost of garbage reduction in the old plant, based upon its nine years of operation and including interest and sinking fund charges, was 52½ cents a ton.

Under the new arrangement and system, the old percolator plant will still be continued in use. However, the essential difference between the two plants is that the cooking, pressing and drying are done in one and the same tank. The cooking is done with live steam which is admitted to the steam jacket surrounding the bottom of the tanks and extending half way up the sides. The recoveries of both grease and tankage, per ton of green garbage, are much greater under the new process of reduction than with the old, as great quantities of these valuable byproducts were lost in the direct heat dryer.

The operating budget for the year 1925 for the new garbage reduction plant is $60,000, and the interest and sinking fund charges on both the old and new plant are $28,800.

A conservative estimate of grease production for 1925 has been placed at 1,300,000 pounds,

although it is fully expected that this figure will be considerably exceeded. The grease output for 1925 has been sold to The Procter and Gamble Company for 6.96 cents a pound, f.o.b. Whitfield. The sale of tankage has been estimated at $13,500, which is the actual amount received in 1924 from this byproduct. This figure, too, should be materially increased.

Based upon the above figures, the total revenues for 1925 are estimated at $104,000, leaving net profit to the city of $15,200. Sinking fund charges for 1925 are based on ten-year serial bonds, which makes the burden extremely heavy in the early years of operation.

Grand Island Municipal Ice Plant

In his report for 1924, C. W. Burdick, commissioner of the Municipal Water, Light and Ice Department of Grand Island, Nebr., shows a net profit from the ice department of $4,483. The ice sales amounted to $33,927. The labor cost $7,025, feed $1,350, labor of distribution $9,464, light and power at the plant $4,655, while other items such as rent of office and barn, operation of Ford and Nash trucks and a horse and wagon, machine maintenance and insurance, brought the total expenses up to $26,566. Adding to this a depreciation of $2,878, left the net income stated above.

The ice plant building is given a value of $19,968; the ice plant machinery, $28,196; horses, wagons and two trucks, $6,101, and miscellaneous equipment brings the total assets up to $54,754. The Ford and Nash trucks were assigned for 1924 a depreciation of 20%, the horses and wagons, 10%; the ice plant machinery, 5%, and the ice plant building 2½%.

The amount of ice manufactured during the year was 4,983 tons and the amount sold was 4,794. The percent of shrinkage was given as 2.42. The cost of manufacturing was $2.97 per ton, including depreciation, of which 93 cents was cost of electricity. Distributing cost $3.59 per ton. The average price received for ice delivered in the city was 39 cents per hundred pounds.

The sale of ice was somewhat lower than in 1923 owing to the cooler summer. On the other hand, the cost of production was reduced by the addition of an accummulator purchased early in the year.

Licensing Operators of Sewage Treatment Plants in New Jersey*

Provisions of the State law and regulations adopted by Health Department. Proposed amendment to prevent discharge for political reasons

By H. P. Croft†

In February, 1918, an act to provide for the examination and licensing of superintendents and operators in charge of water and sewage treatment plants was passed by the legislature. The fundamental idea in this act, Chapter 23 of the Laws of 1918, is set forth in the first paragraph—in order that municipalities, corporations or individuals owning or operating sewage disposal plants may secure the services of capable superintendents or operators. Of secondary importance to those who drafted the act was—so I understand—the desire to retain in their positions capable operators; that tenure of office should continue until the operator's license was revoked, this revocation only to occur after a hearing before the State Department of Health.

The act provides that a license shall be issued to those who were operating plants at the time of its passage when the operator's name shall have been certified to the Department by the proper officials; that examinations are to be held by the Department; as to the method to be followed when the revocation of a license is being considered; and fixes a penalty of ten dollars for each day that violation of the law occurs and provides for a restraining order in the Court of Chancery.

In May, 1919, the Department adopted the following rules and regulations for the examination and licensing of superintendents and operators in charge of sewage treatment plants:

General:

1. No fee shall be charged for the application, examination or license.

2. *Applications*: Application for examination for license to serve as superintendent or operator in charge of a sewage treatment or water treatment plant shall be made in writing on blanks provided by the Department of Health of the State of New Jersey within a reasonable time previous to the date on which the examination will be given. The applicant shall state on the application blank the following:

A. The date.
B. Character of license desired, and processes to be examined upon.
C. Full name, residence and post office address.
D. Nationality, age, date and place of birth.
E. Health and physical capacity for public service.
F. Business and employment for the previous two years.
G. Education.
H. Experience in work of a character similar to that for which examination is to be given.
I. Every application must be signed by three reputable persons.

3. *Examinations*: Examinations will be given under the direction of the Examining Board of the Department of

*Paper before the New Jersey Sewage Works Association.
†Chief Engineer, New Jersey State Department of Health

Health of the State of New Jersey, at such time and place as they may designate. Such examinations shall be practical in character and shall relate to those matters which will fairly test the ability of the persons examined to discharge the duties of the positon for which a license is requested. The examination may be partly writen and partly oral.

The Department may refuse to examine or issue a license after examination to any person who has attempted to practice any deception or fraud in his application or in his examination.

All persons successfully passing the examination shall have licenses issued to them in the class and for the character of work for which his examination was given, and no person receiving a license shall fill a position calling for higher or different qualifications or greater knowledge than covered by the license granted to him. A person holding an operator's license may, upon request, take an examination for a superintendent's license.

The names of all persons successfully passing the necessary examination shall be listed in the files of the Department as eligible for appointment, and recommendations for appointment to positions shall be made on the basis of the standing of each candidate as shown by the examination rating. The names of persons holding licenses shall be published once each year in one of the publications issued by the Department.

Licenses for Superintendents and Operators of Sewage Treatment Plants

There shall be four classes of licenses issued to persons examined as superintendents or operators of sewage treatment plants:

A First Class, or Superintendent's, License shall be issued only to those persons having the qualifications and knowledge necessary for the satisfactory supervision of the operation of a sewage treatment works, including the following processes: Screening, sedimentation, filtration, and disinfection, and for making the standard tests, both chemical and bacteriological, necessary for testing the efficiency of the various processes utilized in sewage treatment works; and informed in general as to the mechanical devices used in sewage treatment works.

A Second Class Operator's License shall be issued only to those persons having the qualifications and knowledge required in order to satisfactorily operate or control one or more of the processes required for a Superintendent's License; and having knowledge sufficient for the making of the standard tests, both chemical and bacteriological, for testing the efficiency of the various processes utilized in the sewage treatment works which he expects to operate.

A Third Closs Operator's License shall be issued only to those persons having the qualifications and knowledge required in order to satisfactorily operate or control one or more of the processes required for a Superintendent's License; and having knowledge sufficient for the making of simple routine standard tests, both chemical and bacteriological.

A Fourth Class Operator's License shall be issued only to those persons having the qualifications and knowledge required in order to satisfactorily operate or control a settling or sedimentation tank, of one or two-story construction.

The failure of officials to certify the names of their operators to the Department resulted in the Board on November 9, 1920, adopting the following resolution:

"RESOLVED, That municipalities or companies owning or operating water purification or treatment plants purifying or treating water used for potable purposes by inhabitants of this State, or of any sewage treatment plant discharging an effluent into any of the waters of this State, who shall have failed to appoint any persons licensed by this Department as superintendents or operators in charge of such plants by February 9, 1921, then such failure by any municipality or company shall result in the matter being referred to the Attorney General for action, as provided under the provisions of Chapter 23 of the laws of 1918.

In two municipalities the failure to comply with the provisions of the act, and after passage of the resolution by the Board, resulted in referring these cases to the Attorney General for action.

Due to the positions being held at the time of the passage of the act, 158 licenses were issued to operators serving 153 municipalities, institutions and corporations. The first examination was held in the State House on June 21, 1921, and examinations have since been held here at intervals of three months. Eighty-eight men have passed the examinations, 2 first class, 1 second class, 40 third class and 45 fourth class. Some of those taking the examinations were for promotion to higher classes; in some cases (and this applies more to the plants owned by corporations) two or more men employed by the corporation have taken the examination. In all, the number of applicants passed were to the positions produced by:

1. The construction of sewage treatment plants—30 .

2. Replacements due to the discharge of operators—7. Political change—3, Unknown causes—4.

3. Replacements due to resignations—4.

4. Replacements due to death of operators—5.

Only seven licensed operators out of over 240 have been discharged in five years. To us in the Engineering Bureau of the Department who have seen after every election a turn-over of from 25 per cent to 40 per cent with dismissals between elections, it is not questioned that the fundamental idea of the act is being accomplished,—the securing and the retention of capable sewage plant operators.

You will note that we have recorded three operators discharged for political reasons. This shows you that the licensing act has not removed these positions from political influence. The act has, however, set up barriers which have made such interference more difficult.

I have two proposed amendments to the act. One is to prevent the discharge for political reasons of capable operators of sewage treatment plants owned by municipalities. Omitting the title, etc., the first amendment was as follows:

1—A. No operator or superintendent in charge of any water treatment or sewage treatment plant or plants owned by a municipality or by municipalities jointly or severally shall be relieved or discharged for any reason from his duties as such by the municipality or municipalities owning such plant or plants, but charges must be filed by the officials of such municipality or municipalities who have jurisdiction over such plant or plants in which shall be contained reasons fully described as to why such person should no longer hold the position of operator or superintendent at such plant or plants and the license issued to such operator or superintendent by the Department should be revoked, and, within thirty days after the filing of said charges, such operator or superintendent shall be given a hearing in person or by counsel by and before the said Department of Health or the Director of Health, and if said Department determines, from such evidence as is submitted to substantiate the charges filed at such hearing, that the operator or superintendent is incompetent to manage said plant or plants, or that he has wilfully neglected his duties in supervising the operation of said plant or

plants, the license of such operator or superintendent shall be forthwith revoked by the said Department of Health, and the municipality or municipalities may immediately dispense with the services of such operator or superintendent upon notice from the said Department of Health as to the revocation of such license.

2. This act shall take effect immediately.

The other amendment provided that where a superintendent or operator is employed by any municipality in the state in charge of a sewage treatment plant, "the necessary expenses of said superintendent or operator to attend a conference, to be held at least once a year, shall be paid by the municipality when called by the Department of Health of the State of New Jersey."

These suggested amendments were referred to a special committee.

Making a Sanitary Survey

The procedure for making a sanitary survey suggested by W. H. Larkin, assistant engineer of the Iowa State Department of Health, was outlined by him in a paper before the sixth annual conference on Sewage Treatment, held at Iowa State College. After explaining the purpose and necessity of such a survey, he described the general procedure of making a survey as follows:

"It is the opinion of the writer that, since this system of elements determining the general sanitation of the community or state starts with the water-supply, surface or underground, and ends in our streams as the effluent from sewage-treatment plants, the proper sequence would be to start with our streams and work up stream and inland.

"Complete surveys of our streams would consist of making gagings to determine the high and low-water marks and the amount of flow at different points and over an extended period. Chemical and bacteriological analyses should be made of the water at the same time, together with the determination of the dissolved-oxygen content and the oxygen demand. Along with this work a complete study should be made of the sanitary sewage and industrial wastes which are being discharged into the streams, as to the amounts, and the true contents—chemical and bacteriological.

"Observation should be made as to stream life in comparison with the nature of the water in various locations. Possibly some experimental work on the various types of wastes should be done to determine upon a satisfactory treatment.

"In connection with our water-purification plants, a complete study should be made to determine the effect of various industrial wastes and to gather data on the actual efficiency of the plants under different conditions. Numerous bacteriological and chemical analyses would have to be made in this phase of the work. A close watch should be kept on municipal sewage-treatment plants, and the relative stability test be given their effluent periodically.

"The sanitary surveys should proceed inland. Detailed investigations should be made of all well water-supplies, and the purification power of the different kinds of Iowa soils. Thus the work should continue, taking in swimming pools, tourist camps, private water supplies and the like. Surveys of our bordering streams could be made in cooperation with our neighboring states.

"If such surveys could be made covering the state of Iowa for a period of a few years, we would have some real data. On these data we could then base some intelligent legislation on the conservation of our water, both underground and surface, and on other phases of sanitation, which legislation would serve to better the general health condiitons of our state."

Leakage and Waste

Summary of replies to questionnaire. Methods of detecting leaks in services and mains. Where most of the leaks are found.

In the questionnaire sent out this year particular attention was paid to the matter of waste and leakage of water. Inspection of the tables shows that a very considerable percentage of these cities make a practice of house-to-house inspections more or less frequently to discover any waste from house fixtures. In several instances where such inspection is reported it would appear that the practice is not that of making systematic house-to-house inspections, but rather an inspection of such houses as may appear from meter readings or other indications to have leaks in fixtures or house plumbing. In a few cities which are not entirely metered it is reported that house-to-house inspections are made only of those buildings that are on a flat rate basis.

LEAKS IN SERVICES

The detecting of leaks in mains and in service pipes outside of the building is becoming more general, and it is very gratifying to see the general response which is being given by waterworks superintendents to the educational work along this line which has been carried on by waterworks societies and public works journals such as this one. About 53% of the cities report using one or more of the several kinds of instruments on the market for locating leaks, most of which may be classed under the general term of microphone. The names given by the various superintendents included aquaphone, sonoscope, leak locater or detector, geophone, etc. Eight cities reported that leaks in services had been located by means of a pitometer survey. These surveys, however, seemed to have their greatest value in locating larger leaks in street mains.

LEAKS IN MAINS

Forty-seven cities reported having had pitometer surveys made of their distribution systems, eight of them during the year 1924, while another has arranged for such a survey in 1925.

In locating leaks in mains, several other methods were employed besides the use of microphones or other listening instruments. Eight cities that are completely metered check their meter readings against a master meter and four against pumping records. Fourteen make a practice of testing the distribution system by districts, shutting all the gates around a certain district so that all the consumption in that district must pass through a meter in by-passing one of the gates. One city makes a note of elevations in the distributing reservoir at frequent intervals, which affords a certain amount of check. Six cities use pressure gauges as an indicator of unusual or excessive use.

Eighty cities report that they rely largely or solely upon leaks showing upon the surface. Some state that the soil is such a dense clay that leaks show upon the surface, while others feel confident of such an indication because the soil is so porous. As a matter of fact, those who have made thorough investigations, as by pitometer surveys, have learned that there is no kind of soil which can be relied upon to pass all leakage water to the surface if there is any other outlet available such as into a nearby sewer, following the water main to a stream crossing, etc. Six cities report that they keep a watch on the sewer, recognizing that if there are leaky joints in the sewer, large leaks in mains are likely to enter such joints and increase the flow of the sewer.

In using the listening instruments, several variations of method are employed. Some apply the instrument to fire hydrants, valve stems etc. Others drive steel rods from the surface until they come in contact with the main.

Altogether 184 cities report the use of leak-locating instruments of some kind and about 350 cities describe the methods used in endeavoring to locate leaks in mains, this including the 80 who rely more or less on surface indications.

WHERE LEAKS ARE FOUND

Superintendents were asked to report the location at which leaks were most commonly found in their systems, and a large percentage of them did so. Of these, 45% reported finding their principal leaks in joints in the mains. Other defects in the street mains included broken pipe, 12%; holes in pipe and corroded pipe, 0.5%; pitted steel pipe, 0.5%; cement lined mains, 0.3%; and hydrant connections, 0.3%; while wood pipe was responsible for about 1% of the leaks. Fire hydrants were found leaking in 11% of the cities and valves in 5%.

The remaining locations of leaks were in or connected with the services. "Services", without specifying more particularly, were reported in 15% of the cases, lead services in 1½%, wrought iron services in 0.7%; steel services in 1 case and brass services in two. Three had found leaks in curb cocks and eight in corporation cocks. Fourteen reported leaks in goosenecks, one in wiped joints, one in unused services.

One specified that the leaks were found under railroad tracks, these presumably being in mains. Only one attributed the leak to electrolysis, this being in lead services. Two stated the leaking services had rusted through and one that they were dead.

One reported that the leaky joints in the mains were due largely to water hammer caused by the operators of the street sprinklers. Another that the leakage was caused by the settling of the ground containing the mains over the mines which underly the city. One attributed the leaking of hydrants to the fact that these had been moved by the frost.

Combining the various reports, we find leakage attributed to joints by 271 cities, to mains other than at the joints in 100 cities, hydrants in 67 cities and valves in 31; while leaks in services and service appurtenances were found in 138 cities.

Use of Water Meters

The use of water meters in American cities has been extending rapidly of recent years and the replies to our questionnaire show an almost universal appreciation of the advantages of metering.

Of the 588 cities which had reported at the time of analyzing the statistics, less than 11% reported using no meters, while 38% reported the services as 100% metered. Twenty-nine cities reported services as 99% metered; 16 as 98%; 26 as between 95 and 97%, inclusive; 37 as 90 to 94% metered; 24 as between 80 and 89%; 23 between 70 and 79%; 21 between 60 and 69%; 8 between 50 and 59%; 7 between 40 and 49%; 16 between 30 and 39%; 17 between 20 and 29%; 27 between 10 and 19%, and 49 as less than 10% metered. These figures show nearly 70% of all the cities reporting having 50% or more of the services metered.

To Increase Toledo's Water Supply

The present capacity of the water distribution system of Toledo, Ohio, is 70,000,000 gallons a day. On a number of occasions a peak of 65,000,000 gallons has been reached when none was being used for fire extinguishing. The number of services has increased from 50,709 in 1920 to 60,000 at present. There is therefore urgent need for more pumping and distributing capacity.

It is a question whether the city should continue to take its supply from the Maumee river or should use lake water instead. A comprehensive plan for the future should be adopted as the result of exhaustive study of the problem. An appropriation of $25,000 has been made for such study, but the Water Department wishes to have this increased to $50,000.

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CONTENTS

Underground Pipes and Trucks

Perhaps it is because they are independent financially of the general municipal government that water departments show a tendency to be altogether too independent. If so, they should be, and sometimes are, made to realize that their interests are closely allied to those of other departments in many ways and the spirit should be one of close cooperation. The fire, street cleaning and sewer departments use the hydrants that the water department furnishes and maintains, and the street department maintains the pavements over the trenches which the water department cuts, and should charge that department for the repaving and maintenance.

Two engineers have recently called attention to a problem that the water, sewer and street departments have in common—that connected with heavy trucking. In Baltimore breakage of water mains and in Bloomfield of a sewer main are attributed to the jarring of heavy trucks on a not-too-smooth pavement above. Mr. Siems of Baltimore suggests that this consideration may necessitate laying mains deeper than is the practice in the southern states. Mr. Molitor while inspecting a sewer more than 20 feet below the surface felt decided jarring caused by trucks passing above.

Another interest in sewer department work, in common with the paving officials, is mentioned by Mr. Siems, who attributes several broken mains to the settling of sewer trenches. But this also is rendered more important by the jarring due to trucks, which may cause a break above a settlement that the main would otherwise have spanned in safety for years.

This new danger makes necessary that more attention be paid by water works superintendents to the backfilling of trenches cut across or along their mains and to the maintaining of smooth pavements above them—also by them and by sewer superintendents to the backfilling of their own trenches so solidly that depressions will not occur in the pavements laid over them.

Selecting Engineers

We frequently read and hear, anent failures of public engineering projects to fully meet requirements, that if a capable engineer had been employed the result would have been more satisfactory. But in many such cases the officials *did* employ an engineer whom they supposed to be capable. Generally the answer is that they had not sufficient grounds for their opinion—probably did not know how to obtain them.

An excellent illustration of a city that determined to select wisely an engineer for its new water system is furnished by Knoxville, Tenn. Several months were occupied in considering candidates for the position, of which there were more than forty. The director of public service and engineer of the water department visited the offices of most of these and inspected work that they were performing. Based on this careful investigation they narrowed down their consideration to a few "whose experience, standing, reputation and achievements in years past have made them nationally known as men especially qualified to handle the work in project for the city of Knoxville." Each piece of water works design and construction that had been performed by these was investigated and the professional history of each member of the several firms obtained.

These officials certainly would seem to have omitted no precautions and efforts to obtain for this public work the best talent available, and it is hardly conceivable that the results will fail to justify their painstaking and intelligent discharge of this duty.

Prompt Publication of A. R. B. A. Proceedings

About April 1st we experienced a most agreeable surprise by receiving the Proceedings of the 1925 Convention of the American Road Builders' Association. This convention was held on January 6th to 8th. Twenty-one papers were read and discussed, and these with nearly one hundred illustrations were published in a volume of two hundred pages, excellently printed and bound, in less than three months.

This is an unusual accomplishment for a national society and reflects great credit on chairman S. T. Henry and Wm. Jabine, director of publicity. It is all the more emphasized by the fact that another national society did not distribute its 1923 Proceedings until several weeks after its 1924 convention, and that the Proceedings of the latter, which was held more than six months ago, have not yet been distributed although special effort was supposed to be taken to get them out promptly.

In these days of rapid progress, new ideas brought forward in convention papers and discussions may well cease to be new in six months and may even be superseded by still newer ones if not published within that period. In fact we believe that a large part of such discussions, if not published within six months, might as well not be published at all.

Contract vs. Day Labor on Hetch-Hetchy

In his report on the Hetch Hetchy construction work dated March 13th, M. M. O'Shaughnessy, city engineer of San Francisco, has the following to say concerning contract vs. day labor:

"With regard to policy of contract or day labor work, I will state that as far as this office is concerned I have no fixed policy as between contract work and day labor. I believe that the choice must be determined with reference to the particular piece of work at hand. Both methods have their advantages and disadvantages. In driving long tunnels under contract where the construction period will extend over a period of several years, the contractor must anticipate and provide in his bid price for many uncertainties which may greatly increase the cost of the work. The more important of these contingencies which he must anticipate are: underground flows of water; changes of formation, either to much harder rock or to soft rock, either involving slower progress; the possibility of encountering gas; again. particularly under the long-time contract, possible increases in the cost of labor and material must be reckoned with, and, in addition, premiums on contractor's bonds must be paid.

"On the day labor basis, there is no question but that we can drive tunnel as economically as a contractor, and if increased difficulties are not met or expenses increased due to other causes above enumerated as the contractor has provided for in his bid price, the city will save money. On the other hand, under the contract plan, the cost of the completed work is closely known at the time the contract is entered into.'

California Roads Damaged by Rain

A rainfall of 45 inches in the vicinity of Willits and over 60 inches in the Crescent City section of the California State Highways, did considerable damage early this spring, slides blocking both state highways and railroads. At one point large slides of several thousand cubic yards completely filled highway cuts, and maintenance crews were engaged constantly in constructing temporary roadways around the slides. In several places it was not safe to use a power shovel because of the danger that a sudden movement of earth would push it over the road embankment.

Seven miles south of Crescent City several hundred feet of highway slipped down the side of the mountain into the ocean and traffic had to be carried over the old roadway until the new road could be reconstructed. Less serious damage was done at various other points throughout the district.

Standardizing Manhole Covers

A committee on standardization of manhole frames and covers is being organized under the procedure of the American Engineering Standards Committee at the request chiefly of the large telephone companies, the American Society of Civil Engineers having been invited to associate itself in the work as joint sponsor. A preliminary survey indicates a wide recognition of the need for standardization. For example, the Flockhart Foundry Company is manufacturing 140 types of circular frames and covers, in addition to many square and rectangular ones, which requires carrying a stock of 2,000 patterns. Standardization would make it safe for a manufacturer to accummulate stock during periods of slack orders to an extent which is now impractical.

Repairing Pavement Cuts in Tucson

The City of Tucson, Ariz., in August of last year, adopted an ordinance requiring that, in repaving over trenches cut in paved streets, the ground shall be cut down to a depth of 6 inches below the bottom of the pavement for a width of 12 inches on each side of the trench, and in this depression shall be built a reinforced-concrete slab spanning the trench with a bearing of 12 inches on each side. This slab must be 6 inches thick, mixed 1:2:4 and reinforced with ½-inch bars spanning the trench and placed 12 inches apart centers. On this slab is then laid the pavement constructed in patching the cut.

Water Works Statistics for 1924

Replies received from more than six hundred officials. Sizes and amounts of mains laid last year. Methods and appliances used in detecting leaks and wastage, and where most of the leaks are found.

Through the cooperation of more than six hundred water works superintendents and other officials we have obtained data concerning last year's work which we have tabulated in the tables following.

The figures for mains laid were in reply to the questions: "What length did you lay in 1924 of cast-iron mains?" "What length did you lay in 1924 of steel mains (not including services)?" "What other kinds of pipe did you lay as street mains?"

Questions concerning waste detection were: "Do you make house-to-house examinations for leaks? How often? What other methods do you employ for detecting leaks in services? What percentage of services are metered? What methods do you employ for detecting underground leaks in mains? How often are such leakage surveys made? Where are most underground leaks found? How much leakage has been discovered and stopped? What is the per capita amount of water pumped or otherwise delivered to the distribution system?"

The information concerning leakage and waste detection has been summarized in a discussion that will be found on page 131 of this issue. A brief summary of the meter information will be found on page 132.

Questionnaires have continued to arrive since the tabulation for this issue was completed. The information given by these will be published in supplementary tables in a later issue.

Several informants have sent with the questionnaires interesting items of information. Among them, Hamilton, O., reports that seven million gallons a day consumption was saved by regulating the flush tanks in the sewerage system.

Two reported that all the water pumped reached the consumers, there being no loss from the mains. As compared to these opinions, which must be based on ignorance of the real conditions, we learn that the Hackensack Water Company, which serves 45 communities in northern New Jersey, with all services metered, and using many miles of mains that were laid years ago, accounts for 90.5 per cent of the pumpage—an unusually good record.

At Shelbyville, Tenn., the Tennessee Water Co. claims to have "one of the most efficiently operated million-gallon slow sand filter plants in the country. A negro boy, salary $100 a month, operates the low-lift centrifugal and triplex heavy-duty pumps, filtration plant, maintenance of service line, new connections, etc. Operator lives with family in residence constructed at plant."

A Louisiana town of 4,000 population "has always been pumping muddy raw water from the Mississippi river into our system. It is so heavily charged with silt as to make the use of domestic meters impossible. However, funds are now available and we are going ahead with the construction of a filtration plant of one m.g.d. This plant we expect to have in operation at the end of the coming year."

(Continued on page 140)

Steel Mains Laid in 1924

City	12" or smaller	Larger than 12"
California:		
Manteca	2,000	......
Monterey Park	6,000-2"	......
National City	1,878	338
Pomona	1,000-8"; 5,260-6"; 2,760-4"; 3,080-2"	......
Red Bluff	4,000	......
Watsonville	4,500	......
Colorado:		
Boulder	1,500-12"	......
Colorado Springs	......	12,000-20"
Greeley	3,030	841
Montrose	3,400-8"	......
Connecticut:		
Wallingford	......	8,811-18"
Idaho:		
Lewiston	2,500	......
Indiana:		
Decatur	400	......
Elwood	500	......
Rushville	......	5,000
Shelbyville	500-2"	......
Kansas:		
Humboldt	2,000-2"	......
Independence	½ mi.	......
Paola	10,000	......
Kentucky:		
Jenkins	700-3"	......
Louisville	200-2"	......
Richmond	140-1"; 7,419-2"	......
Louisiana:		
Baton Rouge	70,000	......
Maine:		
Livermore Falls	600-2"	......
Massachusetts:		
Chicopee	......	4 mi. 20"
Michigan:		
Hastings	132-2"	......
Mississippi:		
Vicksburg	3 mi.-2"	......
Montana:		
Anaconda	500	......
Nebraska:		
Auburn	1,200-2"; 1,000-¾"	......
New Hampshire:		
Claremont	2,495-2" to 1¼"	......
Keene	422	......
New Mexico:		
Albuquerque	5 mi.	......
Tucumcari	2,000-2"	......
New York:	......	27,500
Ohio:		
Bellaire	800-2"	......
Columbus	34,174	......
Elyria	......	1½ mi.-36"
Montpelier	600	......
Oklahoma:		
Woodward	......	930-16"
Oregon:		
Corvallis	25,000	......
Pennsylvania:		
Connellsville	2,800-2"	......
Honesdale	6,000	......
Pittsburgh	......	389
Rhode Island:		
East Providence	5,200	......
South Carolina:		
Cheraw	2 mi.	......
Spartanburg	2 mi.	......
Washington:		
Aberdeen	8,000-2"	......
Auburn	1,300-10"	......
Dayton	800	......
Hoquiam	......	240-28"
Tacoma	4,000	1,136-48"; 2,378-60'
Walla Walla	1,920-5"	5,658-20"
Wisconsin:		
Marinette	900-2"; 100-1"	......
Superior	1,015	......

Cast Iron Street Mains Laid in 1924

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
Alabama:				
Athens	M	600-4"	......	......
Gadsden	M	....	1,000-6"; 1,000-10"	......
Arizona:				
Douglas	M	8,500	......	......
Prescott	M	100	2,700-6"; 1,700-8"	......
Arkansas:				
Arkadelphia	P	3,600-4"	......	......
Mena	M	....	8,000-6"	......
Searcy	M	....	500-6"	......
California:				
Monterey Park	M	5,200-4"	......	......
Nat'l City & Chula Vista	P	10,448	4,258	......
Watsonville	M	1,800	......	......
Colorado:				
Boulder	M	1,380-4"	2,500-6"; 4,300-8"	......
Colorado Springs	M	5,341	......	......
Greeley	M	448	9,530	24
Connecticut:				
Ansonia	P	200	3,426	......
Bridgeport	P	1,608-4"	3,577-6"; 26,920-8"	232-24"; 26,920-36"
Bristol	M	98,884	206,789	......
Danielson	P	350-4"	1,600-10"	2,600-16"
Darien	P	375	888	......
East Hartford	M	2,650-4"	850-6"; 200-8"	2,900-14"; 100-16"
Hartford	M	....	10,000-6"; 20,000-8"; 1,900-12"	1,300-16"; 1,000-36"; 1,900-30"
Litchfield	P	1,200	......	......
Putnam	M	....	200-6"	......
Southington	M	3,212	......	......
South Manchester	P	3,761-4"	......	150-16"; 100-20"
Wallingford	..	....	4,658	......
Westport	P	3,082	10,500	......
Florida:				
Lakeland	M	....	90,000	......
Georgia:				
Cedartown	M	2,000-4"	......	......
Griffin	M	....	2,700	......
Thomaston	..	7,500	2,500-6"	......
Thomasville	M	....	4,324	......
Idaho:				
Lewiston	M	1,280	22,320	5,890
Twin Falls City	M	....	1,000-6"	360-20"
Illinois:				
Berwyn	M	....	12 mi.	......
Canton	..	....	2 mi. 6"	......
Decatur	M	....	8,800-6"; 1,454-10"; 1,200-12"	......
Elmhurst	M	5,000	15,000	......
Lake Forest	M	....	9,200	......
Moline	M	....	800-6"	......
North Chicago	M	....	8,000-6"	......
Peoria	P	....	7,271	......
Peru	M	1,000	......	......
Quincy	M	....	14,828	......
Rock Island	M	....	15,000-6"; 1,800-10"; 12,000-12"	......
Savannah	M	2,569-4"	2,321-6"	......
Springfield	M	1,022	22,732	......
Vandalia	M	12,000	......	......
Indiana:				
Auburn	M	1,116	1,824-6"	......
Columbia City	M	1,169-4"	......	......
Connersville	M	....	1,100-6"	......
Decatur	M	264	2,366	......
Goshen	M	450	1,124	......
Greenfield	M	3,000-2"	......	......
Lafayette	M	1,623	1,951-6"	......
Maine (Continued)				
Livermore Falls	M	....	1,016-6"	......
Portland	P	318	19,993	......
Skowhegan	P	3,092	......	......
Maryland:				
Baltimore	M	....	361,000	39,000
Hagerstown	..	....	6,000-6" & 8"	......
Pocomoke	M	500-4"	......	......
Washington Suburban Sanitary District	M	891-1¼"; 5,888-2"	47,194-6"; 31,622-8"; 6,829-10"; 16,725-12"	4,918-16"; 454-24"
Massachusetts:				
Adams	M	500-4"	1,600-6"	......
Andover	M	....	8,631-6"	......
Braintree	M	....	10,480-6"; 86-8"	......
Brockton	M	....	11,234	......
Brookline	M	....	3,624	......
Cambridge	M	1,086-4"	2,458-6"; 1,843-8"; 160-12"	......
Chicopee	M	900-4"	2 mi.-6" 1 mi.-8"	......
Concord	M	....	7,872	......
Dalton	M	500-4"	......	......
Danvers	M	....	50-6"	......
East Bridgewater	M	500	......	2,000
Everett	M	....	6,176	......
Framingham	M	....	13,027	......
Franklin	M	....	6,017	......
Gardner	M	....	6,767	......
Great Barrington	M	....	8,975-6"	......
Haverhill	M	851	16,982	......
Holbrook	M	....	800-6"	......
Holyoke	..	2,400	2,300	......
Hudson	M	....	4,200	......
Manchester	M	....	60-6"	......
Maynard	M	2,403	442-6"	......
Medford	M	562	11,642	......
Milton	M	128	12,993-6"; 2,602-8"	......
Natick	M	....	3,000	......
New Bedford	M	254	16,125	......
Newburyport	M	....	2,715-6"	......
North Adams	M	....	2,618-6"	......
Northampton	M	970	4,599-6"; 3,729-8" 3,476-10"; 2,097-12"	......
North Andover	M	....	1,265	......
Norwood	M	....	0.86 mi.	......
Saugus	M	....	8,272	......
Somerville	M	165	197-6"; 1,124-8"; 465-10"; 2,174-12"	......
Spencer	M	....	1,815-6"; 245-8"	......
Swampscott	..	....	3,215-6"	......
Taunton	M	840-4"	2,057-6"; 1,926-8"	90-16"; 711-20"
Waltham	M	0.06 mi-4"	2.94 mi.	......
Wareham	M	10,000-2"	14,000-6" & 8"	......
Williamstown	P	300-4"	700-6"	......
Winthrop	M	....	24-6"; 340-8"	......
Worcester	M	7.8 mi. a	......	......
Michigan:				
Ann Arbor	..	....	20,603-6"	......
Battle Creek	M	....	2½ mi.	1⅓ mi.-24"
Bay City	..	....	6 mi.	......
Coldwater	M	....	120-12"	......
Highland Park	M	....	3,500	1,600
Houghton	M	600	......	......
Jackson	M	....	10,623-6"	4,668-24"; 2,568-20"; 804-16"
Marquette	..	1,400	......	......
Marshall	..	500-2"; 700-4"	1,200-6"	......
Menominee	M	1,000-4"	6,000-6"	......
Mt. Clemens	M	....	7,000-6"	......
Mt. Pleasant	M	2,000	......	......
Niles	M	4,500-4"	1,000-6"	......

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
La Porte	M	1,734	6,542	......
Lebanon	M	600	1,400-6"	......
Marion	M	1,449	8,766-6"	......
Martinsville	M	2,200-4"	......	......
Mishawaka	M	1,903	25,937	......
N. Albany-Jeffersonville	P	....	3,580-6"	......
New Castle	M	1,000-4"	2,250-6"	......
Peru	M	....	600-6"	......
Princeton	P	....	1,960	......
Richmond	P	1,295	5,349	......
Rushville	M	....	5,000-8"	......
Seymour	P	....	132-6"	......
Shelbyville	P	....	......	......
South Bend	M	....	10 mi.	1 mi.
Sullivan	P	10,000-4"	7,000-6"	......
West Lafayette	P	450-4"	1,400-6"	......
Iowa:				
Ames	M	10,600-4"	5,600-6"; 2,800-8" 3,100-10"	......
Boone	..	....	½ mi.	......
Burlington	P	184-4"	4,136-12"	......
Cedar Rapids	M	605	19,274	......
Charles City	M	½ mi.-4"	......	......
Cherokee	M	16	16	......
Council Bluffs	..	....	20,592-6" & 8"	......
Davenport	P	....	15,000-6" & 8"	......
Dubuque	M	1,488-4"	33,212-6"	90-30"; 270-24"
Iowa City	P	....	15,000	......
Marshalltown	M	395-4"	14,629-6"; 16,338-8"; 10,135-12"	4,500-16"; 1,150-20"
Mt. Pleasant	M	2,100-4"	......	......
Muscatine	M	....	1,418-6"	1,000-14"
Sioux City	M	....	51,173-6"	5,484-16"
Storm Lake	M	1,000	......	......
Kansas:				
Atchison	P	....	1,039-6"	......
Augusta	M	4,000-4"	......	......
Cherryvale	M	2,000	......	......
Clay Center	M	1,000	......	......
Dodge City	M	4,500	1,200-6"	......
El Dorado	M	450-4"	......	......
Garden City	M	400	1,200	......
Herington	M	4,000	6,000-8"	......
Hutchinson	P	....	12,000-6"	......
Independence	..	1 mi.	½ mi.-6"	......
Iola	M	2,000-4"	360-6"	......
Junction City	M	900-4"	......	......
Ottawa	M	0.96 mi.-4"	0.72 mi.-6"	......
Paola	M	1,500-2"	......	......
Kentucky:				
Bellevue, Dayton and Fort Thomas	P	2,000	12,000	......
Covington	M	700-4"	6,000-6"	1,050-16"
Franklin	M	2,500	......	......
Hickman	P	....	1,600-6"	......
Hopkinsville	P	1,772-4"	1,094-6"	......
Jenkins	P	4,212-4"	......	......
Louisville	M	1,236-4"	61,623-6"; 1,255-8" 40-12"	......
Richmond	P	....	500-6"	......
Somerset	..	1,600	......	......
Louisiana:				
Baton Rouge	P	....	40,000	......
Crowley	..	1,240	26,350-6"; 2,800-8"; 2,450-10"	......
Leesville	P	1,000-4"	......	......
Rayne	..	5½	......	......
Maine:				
Calais	P	700-2"	......	......
Caribou	P	....	1,000-6"	......
Dexter	M	....	1,400-6"; 600-8"	......
Farmington	M	1,600-4"	......	......
Gardiner	M	....	7,000-8"	......
Kittery	M	1,080	......	......

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
Onaway	M	998-4"	......	......
Petosky	M	....	320-6"	......
Rochester	M	2,697	......	......
St. Louis	M	1,000	......	......
South Haven	..	506-4"	1,590-6"; 306-8"	......
Traverse City	M	....	5,000-6"	
Minnesota:				
Albert Lea	M	....	1,360-6"	......
Anoka	M	6,879-4"	499-6"	......
Brainerd	M	9,360	9,198-6"; 672-8"	......
Chisholm	M	....	2,000-6" & 8"	......
Cloquet	M	314-4"	1,735-6"	......
Minneapolis	M	....	116,263-6"; 11,088-8" 12,290-12"	950-16"
St. Peter	M	....	1,500	......
Stillwater	M	....	4,188	......
West Minneapolis	M	....	680-6"	......
Mississippi:				
Canton	M	....	......	......
Jackson	M	....	3,000-6"; 7,000-8"	......
Vicksburg	M	....	1 mi.	......
Missouri:				
Richmond	M	2,700-4"	......	......
St. Louis	M	24	60,734	744
Montana:				
Anaconda	P	....	......	......
Billings	M	2,883	11,648	1,235
Kalispell	M	890-4"	2,995-6"; 12,915-8"	2,300-18"; 1,780-16"
Nebraska:				
Auburn	M	250-4"	......	......
Chadron	M	1,100	......	......
Columbus	M	....	2,000-6"	......
Grand Island	M	1,500-4"	7,072-6"; 2,080-8"	......
Holdredge	M	4,000-4"	2,400-6"	......
Lincoln	M	2.48 mi.-4"	2.48 mi.-6"	......
Omaha	M	64	166,222	9,323
Schuyler	M	2,000	2,500	......
Superior	M	1,000	......	......
New Hampshire:				
Claremont	M	....	14,584	......
Franklin	M	3,100	6,000-6"	......
Keene	M	....	2,694	......
Newport	M	....	750-6"	5,068
Portsmouth	M	1,400-4"	2,000-8"; 1,200-6"	......
Somersworth	..	....	1,600-6"	......
New Jersey:				
Bridgeton	M	....	600-6"	......
Glen Ridge	M	194	3,260-6"	2,000-14"
Hackensack	P	....	147,000	700-24"
Hightstown	M	1,800	600-6"	......
Irvington	..	....	12,000	......
Madison	M	5,000-4"	......	......
Newton	M	2,000-4"	......	......
Nutley	M	....	9,400-6"; 5,900-8"	......
Phillipsburg	P	....	4,000-6"; 900-8" 1,100-10"	......
Red Bank	M	2,500-4"	3,100-6"	......
Rockaway	M	1,600-4"	1,080-8"	
New Mexico:				
Tucumcari	M	45,400-4"	10,800-6"; 3,600-8" 1,500-10"	......
New York:				
Amityville	P	1,960	3,137-6"	......
Auburn	M	....	6,087	......
Avon	M	....	11,000	......
Conastota	M	1.300	......	......
Carthage	M	1,000-4"	......	......
Catskill	M	832-4"	......	......
Chatham	M	300-2"	750-8"	......
Corning	M	....	2,088-6"	......
Cortland	M	1,266-4"	7,076-6"	......
Dansville	M	....	500-6"	......
Elmira	M	....	14,527	......
Fairport	M	500-4"	1,000-6"; 11 mi. 12"	6,000-16"

Cast Iron Street Mains Laid in 1924—(Continued)

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
New York—(Continued)				
Geneva	M	....	3,020-6"; 786-8" 952-10',	......
Hoosic Falls	M	500-2"; 300-4"	1,100-6"	......
Hudson	M	900-4"	600-6"	......
Mohawk	—	1,100	......	......
Newburgh	M	....	168-6"; 3,100-8"	......
New York	M	5,944	785,375	86,631
Ogdensburg	M	263	817	......
Olean	M	3,000	4,000	......
Oneonta	M	....	1,700-6"	......
Ossining	M	2,000	700-6"	......
Oswego	M	500	300-6"; 300-8"; 300-10"	......
Perry	M	....	400	......
Potsdam	..	....	900-10"	......
St. Johnsville	M	....	2,000-6"	......
Salamanca	M	....	3,200-6"	......
Saugerties	M	1,400-4"	150-6"	......
Scarsdale	M	....	9.36 mi.	......
Syracuse	M	375-4"	5.8 mi.	1,500-16"
Utica	P	279-4"	19,869-6"; 4,217-8"; 3,251-12"	90-20"; 13,384-24" 11,522-30"
Waterford	M	1,750-4"	370-8"	......
Watertown	M	4,186	2,564-8"	......
Waverly	M	....	3,850	......
North Carolina:				
Albemarle	M	....	2 mi.	......
Greensboro	M	1,400-4"	18½ mi.	7 mi.
Henderson	..	....	2,000-6"	......
High Point	..	....	5 mi.-6"	......
Mooresville	M	....	1,000	......
Newton	M	....	6,000-6"	......
Raleigh	M	....	13,826	5,280-24"; 6,980-30"
Rocky Mount	M	....	3,300-6"	......
Spencer	M	2,700-4"	......	......
Wilmington	M	....	5,600-6"; 1,848-8"	......
North Dakota:				
Fargo	M	....	356	......
Grand Forks	M	5,203	370	......
Minot	M	....	300	......
Williston	M	1,300-4"	......	......
Ohio:				
Akron	M	....	9.03 mi.-6"; 3.40 mi. 8"; .09 mi.-10'; 3.27 mi.-12"	
Barnesville	M	1,000-4"	2,000-6"	......
Bedford	M	....	18,056-6"; 9,172-8"	......
Bellaire	M	....	2 mi.-6"	......
Cincinnati	M	1,000	6,000	10,000
Columbus	M	18,270	117,561	16,049
Conneaut	M	400	1,375	
Coshocton	M	600		
Dayton	M	1,281-4"	27, 859-6"; 10,562-10"; 3,608-12"	10,054-16" 2,076-20"
Delaware	P	....	400-6"	......
Elyria	M	....	......	......
Fremont	M	2,191-4"	2,200-6'	......
Hamilton	M	8,000-4"	12,000-6"	......
Kent	M	250	4,257	......
Lakewood	M	114-4"	6,227-6"; 134-10"	2,443-16"; 8,804-24'
Lancaster	M	750-1¼,		
	M	2,000-4"	3,200-6"; 1,675-12"	......
Lima	M	3,688	33,279	60

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
Pawtucket	M	....	19,000-6"; 4,200-8" 3,400-12"	......
Westerly	M	....	3,219-6"; 1,134-8"	......
Woonsocket	M	....	5,000	2,000-30"
South Carolina:				
Bennettsville	—	200	1,500	......
Charleston	M	2,311	13,732	......
Cheraw	M	1 mi.	......	......
Columbia	M	73-4"	5,096-6' 141-12"	......
Spartanburg	M	6 mi.	......	......
South Dakota:				
Watertown	M	1,200	5,500	......
Tennessee:				
Covington	M	3,000	......	......
Dyersburg	M	4,500	......	......
Elizabeth	P	200-4"	200-6"	......
Jackson	M	1,500-4"	12,480-6" 975-8" 4,200-12"	......
Memphis	M	291	76,314	8,386-24"
Shelbyville	P	2,200-4"	250-6"	......
Texas:				
Ballinger	M	....	1,500	......
Bonham	M	2,000-4"	......	......
Cleburne	M	5,200	3,400	......
Galveston	—	6,000	1½ mi.	300
Graham	M	6,000	......	......
Mexia	—	3,200	8,650	......
Orange	P	1,800	2,750-8"; 5,000-6"	......
Quanah	M	1,800	1,500-6 & 8"	......
Sweetwater	—	9,000-4"	2,100-6"	......
Weatherford	P	3,924	......	......
Utah:				
Tooele	M	1,800-4"	......	......
Vermont:				
Barre	M	....	1,340	......
Barton	M	1,400	......	......
Bennington	—	2,000	......	......
Newport	M	500	35,000-6" 6,000-8"	......
Richford	—	....	2,000	......
Waterbury	M	700	......	......
Virginia:				
Charlottesville	M	2,000	3 mo. 6"; 500-10"	15 mi.-18"
Clifton Forge	M	1,200	1,050-6"; 1,200-10"	......
Martinsburg	—	5,500	7,200	......
Richmond	M	2,933-4"	55,649-6" 24.800-8" 1,817-10" 4,959-12"	8,310-16"; 102-30"
Washington:				
Aberdeen	M	3,500-4"	6,000-6 2,000-12"	
Auburn	M	....	......	......
Bellingham	—	2,200-4"	7 2-3 mi.	3,300-36"
Dayton	M	....		......
Hoquiam	P	1,904	3,448	......
Tacoma	M	170	4,488	......
Tekoa	M	1,600-4"	900-6"; 350-8"	......
West Virginia:				
Charleston	P	4 mi.-2"	......	......
Moundsville	P	3,000-4"	......	......
Salem	M	....	400	......
Wisconsin:				
Antigo	M	1,000-4"	1,800-6"	......
Appleton	M	517	18,948-6" 1,380-8"	......
Baraboo	M	300	1,200-6"	400-14"

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
Lorain	M	1,500	7,700	......
Marietta	M	6,000-4-6"	......	......
Medina	M	1,200-2-4"	700-6"	......
Navarre	M	1,100-4"	......	......
Niles	M	....	7,564	......
Struthers	P	1,032-4"	12,078-6"; 384-8"	......
Tiffin	P	1,508	1,717	......
Toledo	M	....	31,275-6" 444-8" 6,702-12"	17,955-16" 3,960-24"
Urbana	M	4,235	......	......
Oklahoma:				
Guthrie	—	1mi. 4"	1½ mi.-6"	......
Woodward	M	5,500-4"	2,975-6"	3 1/3 mi.-16"
Oregon:				
Marshfield	—	....	1,000-6"	......
Pennsylvania:				......
Allentown	M	....	15,192	......
Ambler	P	7,015	22,347	......
Ambridge	M	2,450-4"	1,500-6"	......
Beaver	M	1 mi.-4"	......	......
Brackenridge	M	600-4"	......	......
Chambersburg	M	900	800	......
Coatesville	M	....	900	......
Connellsville	P	....	950-6"; 660-8"	......
Duquesne	M	400	4,000-6"	......
Ellwood City	—	550	7,150	......
Franklin	M	....	1,000-6"	......
Freeport	P	1,500-4"	......	......
Grove City	—	1,000	......	......
Hanover	P	4,700	7,500	......
Hollidaysburg	M	7,000	......	......
Huntingdon	M	60	......	......
Indiana	P	4,004-4"	931-6"; 24-8" 660-12"	......
Jenkintown	P	2½ mi.	½ mi.	......
Jersey Shore	P	200	600	......
Johnsonby	M	600	......	......
Juniata	M	2,000-4"	......	......
Kittanning	P	....	......	200-16 & 20
Lancaster	P	340	8,371	1,176
Lebanon	M	2,000-4"	3,000-6"	......
Lehighton	P	350	2,500	......
McDonald	P	....	175-10"	180-16"
Mauch Chunk	P	....	4,000-10"	......
Meadville	M	....	2,010	......
Meyersdale	P	3,000-4"	1,000-6"	......
Midland	P	....	625-12"	......
Minersville	P	....	2,000-6"	......
Monaca	M	1,000-4"	......	......
Mt. Carmel	P	3,320-4"	2,632-8"; 2,058-6"	......
Norristown	P	800	10,000	2,000-20"
Pittsburgh	M	1,930	39,098	150
Red Lion	P	....	200-6"	......
Ridgway	M	100	2,200-8"	......
Sayre	P	500	......	......
Sewickley	M	200-4"	......	......
Shamokin	P	....	25, 000	......
Sharpsville	M	500-4"	......	......
Somerset	M	....	2,000-6"	......
Summit Hill	P	....	960-6"	......
Tamaqua	M	....	1,000-6"; 800-8"	......
Uniontown	P	800-4"	......	......
Warren	P	....	684-6"; 700-10"	......
West Newton	P	....	......	......
Wilkinsburg	—	980	11,778	4,228
Rhode Island:				
Anthony	P	337-4"	225-6"	......
East Providence	P	664	1,370	4,200-16"
Narragansett & South Kingston	P	....	2,000-6"	

City	Municipal or Private	Under 6"	6", 8", 10" & 12"	Larger than 12"
Beaver Dam	M	2,059	947-6"	......
Beloit	P	404	38,735	987
Cudahy	—	....	885-6"	......
Eau Claire	M	698-4"	12,794-6" 1,319-10" 1,376-12"	1,425-16"
Fond du Lac	M	3,363-4"	5,060-6" 2,803-8"	......
Green Bay	M	1,755	13,568	......
Hartford	M	1,000-4"	......	......
Janesville	M	470	11,016	......
Kaukauna	M	....	1,110-6"	......
La Crosse	M	48-4"	8,344-6"; 2,496-8"	......
Madison	—	350	20,005	200
Manitowoc	—	....	8,938-6"; 1,615-8"	......
Marinette	P	....	2,580-6"	300-20"
Merrill	P	....	1,250-6"	......
Milwaukee	M	....	71,787	1,194
Monroe	M	2,792	2,555	......
Neenah	M	....	5,200-6"	......
Oconomowoc	M	9	1,515	......
Plymouth	M	2,228-4"	1,234-6"	......
Racine	M	....	2,606-6"; 1,946-8"; 17-12"	......
Reedsburg	M	350-4"	......	......
Sparta	M	5,000	......	......
Superior	P	....	5,275	......
Two Rivers	M	3,275	6,647-6"; 472-8"	......
Watertown	M	2,031-4"	8,350-6"	......
Waukesha	M	8,000-6"	......	......
Wauwatosa	M	....	11,127-6 & 8"	......
Whitewater	M	Ap. 700-4"	950-6"	......
Wyoming:				
Rock Springs	P	2,987-4"	2,555-6"	......
Sheridan	M	500	3,500	......

[a]—All sizes.

Other Kinds of Mains Laid in 1924

City	Kind	Size in.	Length feet
Alabama:		1½	5,000
Gadsden	Galvanized	2	400
Colorado:			
Boulder	Galvanized	2	3,000
Connecticut:			
Ansonia	Wrought iron	2	231
Southington	Steel & w. i.	2	3,600
So. Manchester	Wood	18	23,000
Florida:			
Lakeland	Galvanized	2	100,000
Illinois:			
Peoria	Galvanized	2	890
Indiana:		1½	228
Bluffton	Galvanized	2	800
		3	1,800
Columbia City	Galvanized steel	1¼	250
New Albany	Galvanized w. i.	2	5,000
		1½	1,000
Rushville	......	10	250
Sullivan	Wrought iron	2	4,000
Iowa:		2	600
Charles City	Galvanized	2	1,000
Keokuk	Wrought iron	1	2,094
Sioux City	Galvanized	2	39,424
Kansas:		1¼	200
Atchison	Galvanized w. i.	1½	800
		2	360
Clay Center	......	2	2,000
Kentucky:			
Hopkinsville	Galvanized	2	282
Louisiana:			
Rayne	Wrought iron	1 & 2	6,000
Maine:			
Caribou	Galvanized	2	150
Portland	Rein. concrete	54	3,000
Massachusetts:			
Framingham	Galvanized	2	1,000
Gardner	Wrought iron	1¼ & 2	796
New Bedford	Lead	1	55
Mississippi:			
Canton	Suction	10	300
Nebraska:			
Chadron	Galvanized	2	1,000
New Hampshire:			
Portsmouth	Wrought iron	1	1,000

Other Kinds of Mains Laid in 1924

New York:			
Cortland	Wrought iron	1	325
Dansville	Wrought iron	2	200
Elmira	Wrought iron	..	1,038
Hoosic Falls	Galvanized	2	700
New York	Galvanized	2	67,000
	Submarine	42	466
North Carolina:			
High Point	Galvanized	2½	5,000
Mooresville	Galvanized	2	3,000
Raleigh	Galvanized	2	4,115
		1	1,302
Rocky Mount	Galvanized	2	7,000
Ohio:			
Conneaut	......	2 & 3	7,961
Niles	Galvanized	1¼	688
Urbana	Galvanized	2	1,140
Oregon:			
Albany	Black dipped galv.	4	1,560
		2	6,000
Corvallis	Wood	14	31,000
Marshfield	Wood	14	10,000
Pennsylvania:			
Franklin	Galvanized	2	2,500
Jersey Shore	Wrought iron	2	600
McDonald	Wrought iron	1	700
Pittsburgh	Wrought iron	2	11,245
Susquehanna	Wrought iron	1½	501
Rhode Island:			
Anthony	Galvanized	2	2,412
Westerly	Galvanized	1¼	1,261
		1½	1,541
South Carolina:			
Charleston	Wrought steel	1½	1,246
Tennessee:			
Jackson	Galvanized	2	5,340
Shelbyville	Galvanized	1¼ & 2	4,000
Texas:			
Graham	Galvanized	2	1,000
Utah:			
Tooele	Wood	4	700
	Galvanized	2	300
Vermont:			
Barre	Wrought iron	2	444
Washington:			
Aberdeen	Wood	6	2 mi.
		4	½ mi.
Bellingham	Galvanized	..	7,000
Dayton	Matheson	4	800
Hoquiam	Creosoted wood stave	26 & 28	11,918
Tacoma	Wood stave	6	2,725
		39	7,315
		46	2,136
Walla Walla	Concrete	36	952
West Virginia:			
Moundsville	Wrought iron	2	2,000
Wisconsin:			
Appleton	Galvanized	2	92
Fond du Lac	Galvanized	1	5,198
Green Bay	Wrought iron	3½	597
		2½	2,705
		2	107
		1¼	493
		1	235
	Galvanized	2½	377
		1½	421
		1¼	1,138
		1	877
Wyoming:			
Rock Springs	Galvanized	2	1,524

(*Continued from page 135*)

Cleburne, Texas, had 3,600 meters at the end of 1924 and 3,480 a year previous. During 1924 the cost of reading meters was $586.50; repairing meters, $792.90, and meter maintenance, $1,783.25. As meter rents was received $8,621.25. This gives the average cost per meter of reading, maintenance and repairs as 89 cents, and the average rent as $2.44, leaving $1.55 as the average to cover interest and depreciation, also probably billing and other office and overhead expenses.

The Southampton, N. Y., Waterworks Co. began metering in 1912, and by the end of 1924 had 1,028 meters installed, being 100% metered. In 1912 it pumped 181 million gallons, and by 1918 this had fallen to 102 millions in spite of the increase of consumers. In 1924 only 109 million gallons were pumped, or about 60% as much as twelve years previous.

Detection of Leakage and Waste

City	How often are house-to-house examinations made?	What other methods are used for detecting leaks in services?	Percentage of services metered	Detecting underground leaks in mains: Methods employed	Detecting underground leaks in mains: Frequency of surveys	Where are most underground leaks found?	How much leakage has been discovered and stopped?	Per capita consumption per day
Alabama:								
Athens	Monthly	None	None	None	....	Joints	......	......
Gadsden	None	Microphone	100	None	....	......	None	......
Arizona:								
Douglas	On request	......	100	Various	Continuous	Joints and rusted pipe	......	......
Prescott	None	......	100	None	....	......	......	86 gal.
Arkansas:								
Arkadelphia	Semi-annually	Microphone	75	None	....	Valves and hydrants	......	167
Benton	......	......	100	......	....	......	......	......
Harrison	None	Transmitophone	90	Transmitophone	....	Joints and hydrants	......	31
Mena	Every 3 mos.	......	100	None	....	Valves and hydrants	Very little	......
Searcy	When meter reading excessive	Microphone	100	None	....	Joints	Very little	......
West Helena	None	......	33⅓	None	....	......	......	32 gal.
California:								
Bishop	None	......	Nearly all	None	....	......	......	......
Dinuba	None	......	99	None	....	Pit holes in pipe	Very little	......
Lodi	Annually	None	25	None	....	Service curb cocks	Very little	......
Manteca	Every 4 mos.	Ear phone	90	None	....	Joints	Very little	......
Monterey Park	None	......	80	Shows on surface	....	Holes in old pipes	......	75 gal.
National City	None	......	100	Master meter	....	Corroded pipe	......	100 gal.
Oxnard	Once	......	....	......	....	Service connections	......	158 gal.
Pomona	None	None	95	Shows on surface	....	......	......	......
Red Bluff	None	......	2.5	Shows on surface	....	......	......	250 gal.
Watsonville	None	Install meters	50	......	....	Joints in c. i., rust holes in steel	500,000 gals. per day	......
Colorado:								
Boulder	When reported	None	15	Leak detectors	Monthly	Joints	0.5% of consumption	450 gal.
Colorado Springs	None	None	2	......	....	Services	......	190 gal.
Greeley	Annually	None	8	None	....	Rust	......	210 gal.
Montrose	......	Microphone	20	Shows on surface	....	Pitting in steel pipes	......	100 gal. winter 400 " summer

Connecticut:								
Ansonia	Annually	Aquaphone	69	Listening at hydrants; checking flow by Venturi	....	Joints	Very little lately	150 gal.
Baltic	Occasionally	None	None	None	....	Joints	......	......
Berlin	None	None	None	......	....	Joints	......	......
Bridgeport	Annually	Microphone	20	None; have used pitometer	....	Joints and services	......	140 gal.
Bristol	Semi-annually	......	99.5	......	....	Broken pipes, lead connections	......	82 gal.
Danielson	Annually	None	5	......	....	......	......	......
Darien	Every 3 mos.	Microphone on hydrants, valves, etc.	99	Darley leak detector	Every 3 mos.	Joints	⅓ of consumption in 3 yrs.	51 gal.
East Hartford	3 times a year	Microphone	5	Microphone	Spring & fall	Lead joints	......	90 gal.
Groton	None	None	99	Surface inspection	Monthly	Joints	50,000 gal. a day	120 gal.
Hartford	None	Microphone	100	Microphone & geophone	Annually	Joints	635,000 gal. a day	90 gal.
Litchfield	3 years	None	Small	None	....	......	......	......
Putnam	2 or 3 years	Darley leak detector	6	Darley leak detector	....	Joints, goosenecks, curb stops; some electrolysis	......	136 gal.
Southington	When necessary or convenient	Microphone	12.7	None	....	Lead connections on services	......	95 gal.
So. Manchester	By meter readers	None	100	None	....	Broken services	......	70 gal.
Westport	Annually	Microphone	94	Check meters against pumpage, sonoscope, sectional metering	Annually	Joints, broken pipes, valves, hydrants	10,000 gal. per hr.	75 gal.
Willimantic	......	......	90	None	....	Joints	......	1,500,000 gal.
Florida:								
Lakeland	Annually	Microphone	100	......	....	......	......	62 gal.
Plant City	None	......	98	Show on surface	....	Joints and valves	Not much	80 gal.
Georgia								
Cartersville	Annually	Microphone	40	Microphone. Show on surface	Seldom	Joints	......	5,650 gal.(a)
Cedartown	When necessary	......	80	Darley leak locator	....	Joints and hydrants	......	30 gal.
Griffin	None	None	100	Pitometer	5 years	Valves	26,000 gal. a day	50 gal
Hawkinsville	None	None	95	None	....	Joints	......	......
Moultrie	None	None	98	None	....	Joints	......	......
Pelham	None	......	100	......	....	Joints	Little	5,000 gal.
Sandersville	None		100	Watch ditches	....	......	50 leaks	150,000 gal.
Thomaston	None	Microphone	100	No leaks	....	......	......	......
Thomasville	None	......	100	......	....	......	......	60 gal.
Idaho:								
Burley	None	......	100	None	....	Joints	......	200,000 gal.
Lewiston	None	Sonoscope	100	Drill through pavements	....	Joints blown; water hammer due to street sprinkler operators	12,000,000 gal. per. mo.	146 gal.
Preston	Annually	......	None	......	....	Joints	......	4 sec. ft.
Sandpoint	None	None	10	None	....	Broken wood pipe	......	......
Twin Falls	None	None	100	Wireless electric	Annually	Joints	......	105 gal.
Wallace	None	......	2	......	....	Broken pipes	......	......
Weiser	None	Microphone	100	Microphone	Occasionally	Pitted steel	......	100 gal.
Illinois:								
Berwyn	Every 6 mos.	Aquaphone	98	Shows on surface	....	Corp. cocks and hydrants	......	56½ gal.
Canton	None	......	100	......	....	Joints and hydrants	......	......
Chester	Semi-annually	......	None	......	....	Joints	......	50,000 gal.
Cicero	......	Microphone	100	None	....	Joints and Corporations	......	67 gal.
Clinton	None	......	90	Shows on surface	....	Rusted pipe	......	......
Decatur	None	Microphone	100	......	....	Joints	......	......
Elmhurst	None	......	100	Shows on surface	....	Lead joints, corp. cocks	......	65 gal.
Geneva	Expect to	Sonoscope	100	Darley leak locator	....	Joints at brass connections	......	100 gal.
Harvey	Every 3 mos.	Microphone	100	Shutting services and measuring water entering district	Annually	Joints	......	50 gal.
Hillsboro	Every 3 mos.	None	(b)	None	....	Joints	......	......
Hooperston	None	Microphone	60	......	....	......	......	......
Johnson City	......	Geophones	100	Geophones	....	Calked joints	small amount	43 gal.
Lake Forest	Annually	Electric leak locator and electric pipe finder	100	Leak locator	Spring & Fall	Bends on services	75 services	285 gal.
Moline	Quarterly	Pitometer Co. just completed survey	....	......	....	......	......	65 gal.
Naperville	None	......	100	......	....	Service pipes	......	......
Nokomis	Will soon	Sonoscope	100	None	....	Joints and hydrants	......	163 gal.
North Chicago	Quarterly	Listening	100	Pitometer survey in 1922	....	Services	26%	88 gal.
Peoria	Annually	......	80	Aquaphone and wireless pipe locator	....	......	......	85 gal.
Peru	......	Microphone	100	......	....	Broken pipe	......	55 gal.
Quincy	None	Aquaphone	78	Shows on surface	....	Steel services	......	55 gal.
Rock Island	......	......	60	......	....	Joints in service pipe	......	100 gal.

Detection of Leakage and Waste—Continued

City	How often are house-to-house examinations made?	What other methods are used for detecting leaks in services?	Percentages of services metered	Detecting underground leaks in mains: Methods employed	Frequency of surveys	Where are most underground leaks found?	How much leakage has been discovered and stopped?	Per capita consumption per day
Illinois (Continued)								
Savannah	On complaint	Leak tester	2	Shows on surface	....	Holes in steel mains	......	....
Springfield	Occasionally	......	..	Survey by Pitometer Co.	....	......	......	120 gal.
Vandalia	None	......	100	Usually shows on surface	....	Services	......	63 gal.
Whitehall	None	None	100[c]	None	....	Joints	......	......
Wilmington	None	None	None	......	....	......	......	
Indiana:								
Auburn	Every 3 mos.	......	50	......	....	Joints and services	......	....
Bluffton	Monthly[d]	Darley microphone	100	Darley instruments	....	Old hydrants and services	......	55 gal.
Columbia	Annually	Microphone	60	Usually shows on surface	....	Hydrants and services	......	....
Connersville	None	Darley sonoscope	100	None	....	Broken pipe	......	....
Decatur	None	......	100	None	....	......	......	....
Delhi	Annually	Audiphone	75	None	....	......	......	55 gal.
Elwood	None	Microphone	75	None	....	......	......	....
Goshen	Annually	None	100	Note surface conditions	....	Fire hydrant leads	5,000,000 cu. ft. in 1924	96 gal.
Greenfield	None	......	67	Usually shows on surface	....	Iron services		....
Greensburg	None	None	100	......	....	......	Considerable	30 gal.
Jasper	None	None	75	None	....	Joints	......	....
Jeffersonville	Every 3 yrs.	Microphone; sectional valve operation	37	Test by sections; closing valves	....	Joints and broken service pipe	......	78 gal.
Knightstown	None	None	100	Show on surface	....	Joints	Very little	68 gal.
Lafayette	When Asked	Leak detector	44	Leak detector	....	Joints and ruptured lead services	3,000 gal. per day	139 gal.
La Porte	Annually	Leaks show at surface	9.5	Listening	....	Lead joints	......	....
Lebanon	None	Microphone	98.9	None	....	Joints	......	....
Linton	Occasionally	Aquaphone	17	Show on surface	....	Services. One leak in mains in 22 yrs.	......	85 gal.
Marion	Annually	Microphone	50	......	....	......	......	75 gal.
Martinsville	Every 6 mos.	None	None	None	....	Joints	......	....
Mishawaka	None	......	100	None	....	Services	......	62 gals.
Newcastle	Annually	Sonoscope	33 1-3	None	....	Joints	6 or 7 in mains	84 gals.
North Manchester	Every 3 mos.	Darley leak detector	70	None	....	Joints	5 leaks	....
Peru	No schedule	Microphone	5	Surface indications	Continually	Broken pipe	......	125 gal.
Princeton	None	......	66	......	....	Joints and valves	......	123 gal.
Richmond	2 or 3 yrs.(e)	Microphone	70	Pitometer in 1920	....	Joints and broken pipes	......	102 gal.
Rushville	Twice a year	Leak detector	100	Pressure and leak detector	Annually	Valves and hydrants	......	170 gal.
Seymour	Twice a year	Sonoscope	20	......	....	Joints	......	....
Shelbyville	Monthly[d]	Microphone	75	......	....	......	......	100 gal.
South Bend	None	......	100	Divide in sections and meter through hydrant	Annually	......	Very little	85 gal.
Sullivan	Annually	None	100	Listening	Annually	Joints	Very little	300 gal.
Tipton	Annually	Microphone	85	......	....	None in main for years	Small services	145 gal.
Veedersburg	Periodically	Leak detector	30	Detector	....	Iron service pipe	......	....
West Lafayette	Occasionally	......	30	......	....	......	......	....
Iowa:								
Ames	None	(d)	100	**Leak detector**	....	Goose necks and curb cocks	......	50 gal.
Belle Plaine	Every 3 mos.	Pressure gauges	100	......	....	Hydrants and services	20,000 gal. per day	
Boone	......	Electric leak locator	100	......	....	Joints and broken pipes	3 leaks in 5 yrs.	40 gal.
Burlington	None	None	7	None	....	Joints and services	......	105 gal.
Cedar Rapids	None	Complete pitometer survey	100	Shows on surface unless it reaches sewer	....	Services	10,000 gals. per day	85 gal.
Charles City	None	......	100	None	....	House services	3 or 4 services a year	....
Cherokee	None	Microphone	100	None	....	......	......	....
Council Bluffs		Leak finder. Shows on surface	100	Shows on surface	....	Joints	......	90 gal.
Davenport	Annually	Sonoscope	90	Geophone	Continuous	Unused services	......	78 gal.
Decorah	Every 3 mos.	Microphone	95	None		Hydrants	......	50 gal.
Denison	Every 3 mos.	......	100	......	....	Broken pipe	......	....
Dubuque	(d)	Microphone	99¾	Microphone on hydrants	Whenever consumption increases	Broken pipe and services	......	....
Eagle Grove	None	Microphone	90	Sonoscope	Quarterly	Broken pipe and hydrants	......	....
Humboldt	Annually	None	100	None	....	Joints	......	....

Iowa City	When asked	Electric leak locator & ear phone	100	Same as for services	....	Services	5% of pumpage	50 cu. ft.
Keokuk	Annually	Aquaphone	95	Aquaphone	Annually	Joints	......	90 gal.
Marshalltown	Occasionally	Sonoscope	94	Sewer inspection and listening at valves	....	Joints	......	135 gal.
Mt. Pleasant	(d)	Listen on pipes	....	Watch sewers and surface	....	Wiped joints and rusted services	......	35 gal.
Muscatine	Every 3 mos.	Microphone	79	Microphone	....	Pipe joints and service pipes	......	85 gal.
Sioux City	......	Meter readings	100	Pipe locator	Twice a year	Joints	......	71 gal.
Storm Lake	None	......	98	None	....	Joints	......	100 gal.
Kansas:								
Atchison	Every 2 yrs.	Microphone	25	Darley leak locator	....	Joints	......	95 gal.
Augusta	Every 3 mos.	Microphone	100	Darley leak locator	Annually	Mostly services	......	....
Cherryvale	......	Microphone	100	......	....	Joints and hydrants	......	....
Clay Center	Annually	......	100	......	....	Joints	15 last year	10 gal.
Dodge City	None	Darley leak locator	100	Leak locator	Yearly	Valves	......	116 gal.
El Dorado	......	......	99.5	......	....	Joints	......	....
Garden City	None	None	85	None. Shows on surface	....	......	......	....
Herington	None	Microphone	100	Shows on surface	....	Joints	Very little	85 gal.
Hiawatha	None	......	100	Shows on surface	....	Joints	......	54 gal.
Humboldt	None	Sonoscope	100	Sonoscope	....	Broken pipes	15%	75 gal. (f)
Hutchinson	Annually	Darley leak detector	100	Darley leak detector	Annually	Leaking services	Not much	55 gal.
Independence	None	Electric leak locator	100	Usually show on surface	....	......	......	....
Iola	None	Microphone	100	Microphone	....	Rusted pipe	Not much	
Junction City	None	(d)	100	None	....	Wiped joints, lead services	50 leaks last year	120 gal.
McPherson	None	Show on surface	100	None	....	Broken pipe	......	75 gal.
Manhattan	None	Microphone	100	Microphone	....	......	......	95 gal.
Mulberry	None	......	92	Check meters against master meter	Monthly	Broken pipe	......	10 gal.
Osage City	None	Microphone	100	Show on surface	....	Services	......	....
Ottawa	None	Sonoscope	100e	Auger, sounding rod and sonoscope	....	Hydrants, valves and broken pipe	Very little	90 gal.
Paola	None	Microphone, meters	100	Pressures	Few weeks	Joints, broken pipe	250,000 gal. a day	100 gal.
Pratt	Every 3 mos.	Darley	100	None	....	Hydrants	......	90 gal.
Kentucky:								
Bellevue	Every 6 mos.	Electric leak locator	95	Electric leak locator	Every few mos.	Services	......	....
Covington	......	......	100	Listening on services	....	Under R. R. tracks	......	....
Franklin	Occasionally	Microphone	1	Listening	....	......	......	....
Glasgow	Quarterly	......	33	None	....	......	......	....
Hickman	Twice a year	(d)	60	......	....	Joints and hydrants	......	....
Hopkinsville	None	Microphone	62	Microphone and surface inspection	....	Joints and services	100 leaks a year	42 gal.
Jenkins	Monthly	......	....	......	....	......	......	....
Louisville	Continuousg	......	10.9	Survey by Pitometer Co. in 1922-23	....	Joints and broken pipe	3,600,000 g. p. d.	141 gal.
Morganfield	Twice a year	......	h	......	....	......	......	35 gal.
Paris	Annually	Microphone	20	......	Annually	Joints and services	......	100 gal
Richmond	Annually	Darley	10	......	....	Blown joints	......	125 gal.
Somerset	None	......	65	None	....	Joints and hydrants	......	....
Louisiana:								
Baton Rouge	None	......	85	......	....	Joints	Very little	....
Crowley	Every 4 mos.	......	0.5	Surface inspection	Monthly	Joints	......	72 gal.
Donaldsonville	......	......	2i	......	....	......	......	....
Leesville	None	None	10	Surface indications	....	Hydrants	......	200 gal.
Rayne	None	......	100	Watch drains and streets	....	Joints and hydrants	......	....
Maine:								
Calais	Annually	Darley sonoscope	20	Darley electric leak locator	....	Joints and hydrants	Small	61 gal.
Caribou	Annually	Sonoscope	None	Sonoscope, with steel bar driven in ground	....	Blown joints	......	133 gal.
Dexter	Every 3 or 4 mos.	......	95	Darley electric leak locator	....	Joints, valves and hydrants	......	....
Farmington	Occasionally	Shows on surface	None	Shows on surface	Fall & Spring	Joints	4 in 1924	....
Fort Fairfield	2 or 3 times a year	Aquaphone	1	Surface inspection	....	Joints and hydrants	5 joints, 1 hydrant	....
Gardiner	Annually	Microphone	....	......	....	Joints	......	138 gal.
Houlton	Not regularly	......	Few	All show on surface	....	Joints and services	......	....
Kittery	None	Darley leak locator	....	Darley	....	Joints, broken pipe, hydrants, services	......	....
Livermore Falls	......	......	None	......	....	Joints and broken pipe	......	....
Portland	......	......	30	......	....	......	......	140 gal.
Skowhegan	Every 2 or 3 yrs.	Sonophone, geophone	....	None	....	Joints	......	....
Van Buren	Every 3 mos.	Microphone	....	Show on surface	....	Hydrants moved by frost	......	....

Detection of Leakage and Waste—Continued

City	How often are house-to-house examinations made?	What other methods are used for detecting leaks in services?	Percentages of services metered	Detecting underground leaks in mains: Methods employed	Detecting underground leaks in mains: Frequency of surveys	Where are most underground leaks found?	How much leakage has been discovered and stopped?	Per capita consumption per day
Maryland:								
Baltimore	Semi-annually	Microphone	12	Pitometer survey	Continually	Joints	......	125 gal.
Hagerstown	None	Geophone and transmitophone	90	Survey by Simplex Meter Co. in 1923	....	Broken pipes	500,000 gal.	80 gal.
Pocomoke City	Annually	None	5	None	....	......	......	....
Washington Sub. Dist.	None	Darley leak locator, aquaphones	85	Show on surface	....	Split pipe	......	50 gal.
Massachusetts:								
Adams	Twice a year	Microphone	....	......	....	Blown joints	......	
Agawam	None	Listening	100	Listening	....	Joints		....
Andover	Occasionally	......	95	Test gates and hydrants	Annually	Joints	Not much	....
Braintree	Every 3 mos.	Microphone	92	Microphone on hydrants and services	Often	Joints	Very little	....
Brockton	Occasionally	Microphone	1	Geophone and Darley leak detector	....	Joints	......	50 gal.
Brookline	None	Microphone	100	Listen on gates, hydrants and services	Annually	Broken pipe	1 leak last year	92 gal.
Cambrigde	Monthly	Aquaphone	47.2	Complete pitometer survey in 1920	....	Pipes, hydrants and valves	38 leaks in 1924	103 gal.
Chicopee	Twice a year	......	90	Leak finder	Every 3 mos.	Joints	6 leaks in 1924	....
Concord	None	......	....	Testing by sections	....	......	......	110 gal.
Dalton	Monthly	......	None	Show on surface	....	Joints	Not much	....
Danvers	Every two years	Pitometer surveys	12	Feeding sections through metered line	Annually	Joints and valves	......	145 gal.
East Bridgwater	Every 6 mos.	None	95	None	....	Joints	......	....
Everett	Annually	Aquaphone, service rods at curb cocks	80	None	....	......	......	102 gal.
Framingham	On complaint	......	100	......	....	Joints	......	65 gal.
Franklin	......	Shows on surface	100	Show on surface	....	Rusted services	......	50 gal.
Gardner	(d)	Aquaphones, leak locators	100	Aquaphones	....	Joints, broken pipe	Small	46 gal. (k)
Great Barrington	Twice a year	Patrol and listening	3	Pressure gauge, leak detectors	Often	Joints, broken pipe	......	150 gal.
Haverhill	Twice a year	Sonoscope, electric leak locator	67	Sonoscope	Annually	Joints	Very Little	95 gal.
Holbrook	Twice a year	Microphone	20	Electric leak detector	Annually	Joints	None	....
Holyoke	Twice a year	......	10	Leak locator	....	Service connections	Considerable	130 gal.
Hudson	None	......	100	Geophone, wireless	....	Joints, cement pipe	......	55 gal.
Lee	Occasionally	Detectometer	None	......	....	Joints	......	....
Manchester	Annually	Darley leak locator	95	Darley leak locator	Spare time	Joints	......	....
Mansfield	Occasionally	Microphone	60	......	....	Joints, valves, hydrants	......	....
Maynard	None	......	90	None	....	Lead services	10 leaks	47 gal.
Medford	......	......	100	None	....	......	......	53 gal.
Milton	Occasionally	Geophone & aquaphone	100	Test by districts, use geophone	....	Cup joints in lead services	......	....
Montague	Annually	Microphone	None	Shows on surface	....	......	......	....
Natick	None	......	92	None	....	Cement-lined pipe	25 leaks	....
New Bedford	None	Darley leak detector, aquaphone	93.5 (1)	Same as services	....	Joints	......	67 gal.
Newburyport	None	......	3	......	....	Broken pipes	......	80 gal.
North Adams	......	......	17	......	....	......	......	150 gal.
Northampton	......	......	95	......	....	......	......	....
North Andover	Quarterly (d)	Stethoscope	94.7	Stethescope and aquaphone	....	Joints	......	70 gal.
Norton	Every 6 mos.	None	10	......	....	Joints	......	....
Norwood	Every 3 mos.	......	80	Survey by Pitometer Co. in 1922	....	Corporations	100,000 gal.	80 gal.
Salisbury	Annually	Leak detector	None	None	....	Goosenecks	......	....
Saugus	Occasionally	Sonoscope	53	Pitometer survey, leak detector	....	Joints	......	50 gal.
Somerville	Occasionally	Meter readings; aquaphone	95	Pitometer survey	....	Joints and services	Very little found	77 gal.
Spencer	Quarterly	Microphone	85	None	....	Broken pipe	......	....
Swampscott	4 times a year	Microphone	100	None	....	Leadjoints, services	21 leaks	....
Taunton	None	Aquaphone, geophone, detectophone	89	Same as for services	Occasionally	Joints	......	95 gal.
Waltham	Quarterly	Microphone	100	Electric leak detector	....	Joints, broken pipe	115,000 gal. per day	66 gal.(k)
Wareham	None	Microphone	65	......	....	......	......	....
Williamstown	None	......	75	None	....	Joints, hydrants	......	....
Winthrop	Quarterly	Leak finder	100	Pressure gauge	....	Cracked pipe	9 leaks in 1924	

Worcester	When use increases	Microphone	98	Survey by Pitometer Co. in 1924	....	None of consequence	......	85 gal.
Michigan:								
Ann Arbor	When leaks reported (d)	......	100	Microphone	....	Broken services	......	....
Battle Creek		Microphone	100[e]	Microphone, test rods	When necessary	Joints	Not much	90 gal.
Bay City	None	......	100	......	....	Joints, broken pipe	Small amount	96 gal.
Belding	Every 3 mos.	......	90	......	....	Old services rusted	......	....
Cheboygan	None	......	100[e]	Darley leak locator	....	Broken pipe	......	150 gal.
Coldwater	Every 2 yrs.	Microphone	None	......	....	Valve stems, joints, services	......	140 gal.
Hancock	Twice a year	......	1	Electric detector	Twice a yr.	Joints and old pipe	......	....
Hastings	Annually	Microphone	76	None	....	Joints	Very little	86 gal.
Highland Park ...	Quarterly	Microphone	100	Pitometer tests	Every 2 yrs.	......	......	110 gal.
Houghton	Every 3 mos.	Contemplate survey this year	100	Microphone, surface indication, master meter	....	Rusted services	Very little	82 gal.
Ishpeming	None	None	78	Leak locator	Where reported	Joints	......	....
Jackson	None	......	100[l]	Pitometer survey in 1915	....	......	......	90 gal.
Ludington	None	......	95	......	....	Joints	......	....
Marquette	None	......	59	Show on surface	....	Joints	......	181 gal.
Marshall	None	Microphone	85	None	....	Services	10 in 1924	....
Menominee	Annually	None	75	......	....	......	......	....
Mt. Clemens	None	......	100	Show on surface	....	Broken pipe	......	....
Mt. Pleasant......	......	......	98	......	....	......	......	100 gal.
Niles	......	......	100	Shows on surface	....	......	......	75 gal.
Onaway	Every 3 mos.	Geophone	Very few	Geophone	Every 3 mos.	Valves, hydrants	54,000 gal. per day	....
Paw Paw.........	Quarterly	......	100	......	....	Valve	Very little	....
Petoskey	None	Telephone	100	Telephone	Every fall	Broken pipe	......	....
Rochester	Quarterly[d]	None	87	None	....	Joints	......	....
St. Clair.........	Occasionally	Microphone	(m)	Electric	....	Lead connections near mains	......	175 gal.
St. Louis.........	......	......	75	......	....	Joints	......	....
South Haven......	Occasionally	Microphone, watch sewers	90	......	....	Joints, services	......	....
Traverse City.....	Large meter readings	Darley leak locator	85	None	....	Blown joints	2 in 2 yrs.	555 gal.[n]
Minnesota:								
Albert Lea........	Twice a year	Microphone	100	Check with master meter	....	Hydrants, joints	......	50 gal.
Anoka	Quarterly	......	98	None	....	Valves	......	....
Brainerd	None	......	100	......	....	Services, hydrant stubs	......	....
Chisholm	Annually	Microphone	60	None	....	......	......	100 gal.
Cloquet	Monthly	Leak detector	100	Leak detector	Twice a yr.	Hydrants, services	......	35 gal.
Crookston	Monthly	Microphone	100	None	....	Service taps	......	100 gal.
Lake City.........	Twice a year	......	100	Electric detectaphone, ear phone	Spring and fall	Services, lead connections	20%	65 gal.
Litchfield	Seldom	Shows on surface	100[c]	......	....	Hydrant	......	75 gal.
Melrose	Monthly	......	100	......	....	......	......	....
Minneapolis	None	......	100	Pitometer survey	....	Joints	......	102.5 gal.
Northfield	Every 3 mos.	Darley leak locator	....	Darley leak locator	Every 3 mos.	Broken pipe, joints	34,000 gal. per day	80 gal.
St. Peter.........	Quarterly	Listening	100	......	....	......	......	....
Stillwater	None	Sonoscope	....	Sonoscope, observation	....	Joints on old mains	......	....
West Minneapolis.	None	......	100	......	....	......	......	....
Mississippi:								
Canton	None	Geophone	100	Wireless leak detector	....	Goosenecks	10,000 gal. a day	80 gal.
Charleston	Monthly	......	90	None	....	Joints, services	......	190 gal.
Clarksdale	None	Darley leak locator	100	Leak locator	Quarterly	Joints	......	75 gal.
Jackson	Every 6 mos.	Microphone	78	Bar and microphone	....	Services	300,000 gal.	140 gal.
New Albany	When requested	Microphone	90	......	....	Joints	Very little	58 gal.
Vicksburg	Frequently	Microphone, geophone	35	Geophone	Occasionally	Joints	100,000 gal. a day	112 gal.
Missouri:								
Richmond	None	Microphone	100	None	....	Joints	70,000 gal. a day	
St. Louis	Twice a year	......	7.7	Pitometer surveys	Frequently	......	......	139.8 gal.
Montana:								
Anaconda	None	......	None	Pitometer survey in 1913	....	......	......	400 gal.
Billings	None	Microphone, meter readings	100	Rod and microphone	....	Wood pipe hubs	0.1 per cent.	127 gal.
Havre	None	Meter readings	75	Watch surface	....	None found	......	150 gal.
Kalispell	Twice a year	Meter readings	85	Detectophone	Quarterly	Joints, collars on wood pipe	50 a year	160 gal.
Miles City	None	Microphone	98	Listening	....	Joints	......	86 gal.
Ronan	None	None	1	None	....	Joints	......	75 gal.

Detection of Leakage and Waste—Continued

City	How often are house-to-house examinations made?	What other methods are used for detecting leaks in services?	Percentages of services metered	Detecting underground leaks in mains		Where are most underground leaks found?	How much leakage has been discovered and stopped?	Per capita consumption per day
				Methods employed	Frequency of surveys			
Nebraska:								
Auburn	Annually	Microphone	100	None	....	......	10,000 gal. a day	60 gal.
Chadron	Quarterly	None	75[h]	......	....		......	....
Columbus	None	None	100	None	....	Services	......	....
Fremont	When suspected	Microphone	100	Microphone	Every 6 mos.	Valves, hydrants	......	141 gal.
Grand Island	Spring and fall	None	100	None	....	Broken pipes, valves, hydrants	......	134 gal.
Hastings	None	Microphone	100	None	....	Joints	......	85 gal.
Holdrege	Quarterly	Microphone	100	None	....	......	......	....
Lincoln	None	......	100	......	....	Broken services	......	....
Omaha	On request	None	99[1]	Geophone, surface indications	....	......	......	127 gal.
Schuyler	Every 6 mos.	Microphone	100	Electric leak locator	Annually	Joints, hydrants	......	....
Sidney	None	None	100	None	....	......	......	100 gal.
Superior	Every 3 mos.	Aquaphone	100	None	....	Joints	1 leak in 1924	90 gal.
New Hampshire:								
Claremont	None	None	70	None	....	Joints	......	....
Farmington	None	None	33	Aquaphone	Each spring	Joints	Very few	....
Franklin	Quarterly	......	100	Watch surface	....	Joints, broken pipe	......	29 gal.
Keene	None	......	98	None	....	......	......	100 gal.
Lebanon	Annually	None	33	None	3 times a yr.	Lead connections	......	....
Newport	Annually	Aquaphone	1	Darley electric locator	....	Joints	4 joints in 1924	....
Portsmouth	None	Transmitophone	100	Pitometer survey	Every 5 yrs.	Joints	700,000 gal. a day in 1924	70 gal.
Somersworth	Annually	Sonoscope	60	Electric leak detector	....	Goose necks	......	100 gal.
Suncook	Annually	None	None	......	....	Joints	7 in 1924	....
New Jersey:								
Bridgeton	Annually	Microphone	None	......	....	Joints	......	135 gal.
Glen Ridge	None	Aquaphone, meter readings	100	......	....	Broken pipe	......	75 gal.
Hackensack & 44 other communities	On request	Aquaphone	100	Aquaphone survey	Twice a yr.	Joints	......	90 gal.
Hightstown	None	None	100	Listening	Twice a yr.	Joints	Very little	100 gal.
Irvington	None	Aquaphone, electric leak detector	100	Pitometer survey, leak detector	Annually	Joints, hydrants	250,000 gal.	....
Madison	None	None	100	Darley electric leak locator		Joints, hydrants	Very little	....
Newton	None	......	90		....	......	......	....
Nutley	......	Microphone	100	Pitometer survey	....	Broken pipe	100,000 gal. a day	45 gal.
Phillipsburg	Frequently	Water phone	5	Many	Frequently	......	......	....
Red Bank	None	......	100	......	....	Hydrants, valves	5%	66 gal.
Rockaway	Quarterly	......	100	Check on master meter	....	Corroded services	144,000 gal. a day	40 gal.
Washington	None	Microphone	1.3	None	....	Joints	......	....
New Mexico:								
Albuquerque	Occasionally	Microphone	100	Microphone	Weekly	Joints	......	....
Deming	None	Sonoscope	77	Shows on surface	After use of fire booster	Broken pipe	......	69 gal.
Tucumcari	None	None	100	All new c. i. pipe, replacing wood	....	......	......	35 gal.
New York:								
Amityville	Irregular	Listening, surface examination	0.5	Pumping records	....	Services	......	62 gal.
Auburn	None	Aquaphone, meter readers	99	Aquaphone, stethoscope, electric leak locator	....	Joints	250,000 gal. a day in 1924	118 gal.
Avon	None	Meter readings, aquaphone	100	None	....	Broken pipe	......	83 gal.
Canastota	None	Autophone	100	Check meter readings	Twice a year	Valves	......	75 gal.
Canton	Occasionally	Darley microphone	None	Darley microphone	....	Joints, hydrants	......	102 gal.
Carthage	None	......	60	None. Have abundant supply	....	......	......	....
Catskill	None	......	6	Darley leak indicator, microphone annually	Annually	Joints	50,000 gal. a day yearly average	....
Chatham	Annually	Microphone	75	Microphone	....	Joints	......	....
Corning	Quarterly	Microphone	100	None	Twice a year	Services	500,000 gal.	....
Cortland	Quarterly[d]	......	100	Shows on surface	....	Joints	50,000 gal. a day	....
Dansville	Annually	Sonoscope	6 meters	Electric leak locator	Annually	Joints	50,000 gal. a day	125 gal.

Elmira	None	......	100	Check meter readings. Survey in 1919	....	Joints	300,00 g. p. d. in 1919	100 gal.
Fairport	....	Microphone	95	Observation	....	Hydrants	......	25 gal.
Fort Plains	Every 6 mos.	Microphone	5	Darley electric leak locator	....	Joints	......	....
Geneva	None	Microphone	100	None	....	Hydrants	......	100 gal.
Homer	Periodically	Microphone	99	Testing by districts	....	Joints	Large amount	....
Hoosic Falls	Every 2 yrs.	......	....	......	....	Broken hydrants, cement-lined mains	......	
Hudson	Monthly	Transmitophone	....	Transmitophone	....	Hydrants	......	
Malone	Annually	Microphone	2	Electric leak locator	....	Joints	......	200 gal.
Mohawk	None	Microphone	60	General inspection	....	Joints	100,000 gal. a day	100 gal.
New York	Occasionally	Aquaphone; pressure inside building compared to that in main	26	Pitometer & aquaphone surveys; hydraulic gradients	No systematic surveys	Services, blown joints, broken pipes	15 to 20 m.g.d. yearly by four field parties	131 gal.
Newburgh	Continually	Darley leak locator	7.6	Leak locator	Occasionally	Broken pipes	......	122 gal.
Norwich	None	Pitometer survey	97	Pitometer survey in 1921	....	......	300,000 gal. a day	140 gal.
Ogdensburg	Annually	Aquaphone, Darley leak locator	6	Bar and aquaphone, leak locator	....	Joints	500,000 gal. a day	180 gal.
Olean	None	......	100	None	....	Wiped joints	......	....
Oneonta	Annually	Microphone, pitometer survey	3	Pitomete rsurvey in 1924	....	Nine except services	700,000 gal. house waste	....
Oswego	Semi-annually	Microphone	10	Pitometer survey	Annually	Joints	......	210 gal.
Ossining	....	Microphone	99	Listening	....	Lead joints, services	......	....
Perry	....	Microphone	3	None	....	Broken pipe	......	170 gal.
Potsdam	Annually	Microphone	None	Darley leak locator	....	......	100,000 gal. a day	250 gal.
St. Johnsville	Quarterly	Microphone	98	Leak detector	....	Joints, valves	......	125 gal.
Salamanca	None	Microphone	100	Microphone and survey of mains	Quarterly	Services	Very little	112 gal.
Saugerties	......	Microphone	45	......	....	Joints	......	....
Scarsdale	None	Wireless leak locator, geophone	100	Test by districts	....	Joints, broken pipe	240,000 gal. a day since 1922	78 gal.
Seneca Falls	When convenient	Listening	10	Listen, watch surface and pumpage	....	Broken pipe	......	130 gal.
Southampton	None	......	100	None	....	Pin holes in brass pipe	......	....
Syracuse	None	Sonoscope, electric leak locator	100	Sonoscope, electric leak locator	Annually	Joints	2,240,000 g. p. d. in 1924	140 gal.
Tarrytown	None	......	99	Darley locator; pressure gauges on hydrants	....	Old iron services	22 in 1924	90 gal.
Utica	Excessive consumption	Microphone	100	Pitometer survey by districts	Continually	Joints, broken pipe	20%	100 gal.
Waterford	Annually	Aquaphone	100	Aquaphone, early morning consumption	Twice a year	Joints, service pipes	210,000 gal. a day in 4 yrs.	76 gal.
Watertown	Every 6 mos.	Microphone	60	Microphone	Continually	Joints, lead pipe	2,000,000 gal. a day	131 gal.
Waverly	None	......	50	Electric leak locator	Annually	Joints	......	100 gal.
Wellsville	Quarterly	......	80	Listening, surface indications	....	Service connections	......	....
North Carolina:								
Albemarle	When bill excessive	Electric leak detector	85	Electric leak detector	Annually	Services at main	......	75 gal.
Elizabeth City	None	......	All except domestic	None	....	Joints	Two or 3 a year	200 gal.
Greensboro	No	Sonophone	80	Pitometer survey in 1924	....	Valves, hydrants	......	....
Henderson	None	......	100	None	....	......	......	....
High Point	None	......	100	Pitometer survey in 1924	....	......	15%	100 gal.
Morrisville	None	None	100	Shows on surface	....	Services	Very little	30 gal.
New Bern	None	Aquaphone	15	Shows on surface	....	Joints, rusted services	......	100 gal.
Newton	None	Microphone	90	Inspect surface	....	Joints, hydrants	......	....
Raleigh	Annually	......	56.5	Shows on surface	....	Joints	......	94 gal.
Rocky Mount	None	(d)	100	Leak detector	....	Joints	......	80 gal.
Spencer	None	None	95	Listen	....	Joints	......	55 gal.
Wilmington	Annually	Aquaphone	35	None	....	Joints	......	94 gal.
North Dakota:								
Enderlin	Quarterly	Microphone	100	Microphone	Annually	Broken pipe, hydrants	......	....
Fargo	Every 6 mos.[d]	Sonoscope	100	Check by meterage; pitot survey	Annually	services at corp. or curb cock	620,000 g.p.d. in 1924	100 gal.
Grand Forks	When meters read	Microphone	90	None	....	Goose necks, hydrants	......	....
Minot	Monthly[d]	None	100	None	....	......	......	55 gal.
Valley City	When necessary	......	100	......	....	Joints	20%	71 gal.
Williston	Monthly	......	99	Microphone	Annually	Joints	......	100 gal.
Ohio:								
Akron	None	High meter readings investigated	100	Night flow by districts	....	Broken services	250,000 g. p. d. in 1924	....
Barnesville	None	......	100	......	....	......	......	....
Bedford	None	Microphone	100	......	....	......	......	....
Bellaire	Annually	......	10	Leak locator	Annually	Joints, broken pipe	......	....

Detection of Leakage and Waste—Continued

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Ohio (Continued)								
Bryan	None	......	96	None	....	Joints	Very little	....
Cincinnati	None	......	100	Pitometer survey	....	Services	1,400,000 g. p. d. in 25% of area of city	116 gal.
Columbus	6 times a year	None	99	Pitometer survey in 1923	....	Services	......	90 gal.
Conneaut	None	Aquaphone	99	......	....	Services	......	....
Coshocton	None	......	5	......	....	Broken pipe	......	210 gal.
Dayton	None	Pitometer survey in 1924	90	......	....	Joints	3,000,000 g. p. d.	89 gal.
Delaware	Quarterly[d]	Microphone, recording gauges	100	......	....	Broken pipes, services	......	100 gal.
Elyria	....	Microphone	100	......		......	......	....
Fremont	Quarterly	Leak locator	100c	Darley leak locator	Constantly	Old services	Several in 1924	....
Gibsonburg	Quarterly	......	100	None	....	Hydrants	......	38 gal.
Hamilton	Annually	......	95	......	....	Joints	......	100 gal.
Kent	Quarterly	Microphone	100	Microphone, testing by sections	....	Joints, hydrants	30% in two yrs.	85 gal.
Lakewood	Annually	Aquaphone	100	Listen at hydrants	3 times a year	Services over sewers	200 leaks a year	70.6 gal.
Lancaster	None	......	100	None	....	Hydrants, services	......	84 gal.
Lima	None	Microphone	100	Pitometer survey	....	Joints	2 main leaks by Pitometer	100 gal.
Lorain	None	......	90	None	....	......	......	....
Marietta	None	None	85	None	....		......	....
Medina	None	Sonophone	98	Sonophone	....	Joints, services	......	....
Montpelier	Annually	Listening	80	Microphone	2 years	Joints, pipes	......	150 gal.
Navarre	Twice a year	......	None	None	....	Services	......	
Niles	None	Microphone	100	Microphone	....	Valves	......	120 gal.
Salem	Quarterly	Microphone	80	Microphone	Monthly	......	......	....
Sidney	None	Microphone, meters	100	......		......	......	....
Struthers	Quarterly	Pitometer	100	Pitometer	Annually	Joints, lead service connections	4% of consump. in 1924	....
Tiffin	None	Listening[d]	100	None	....		......	61 gal.
Toledo	......	......	97	Pitometer surveys	1918, 1924	......	3,000,000 gal.	110 gal.
Troy	Annually	......	100	......	....	w. l. services	......	....
Upper Sandusky	None	Geophone	100	Geophone	....	Services	......	....
Urbana	None	......	25	......	....	Joints	......	150 gal.
Oklahoma:								
Chickasha	None	Microphone	99	None	....	Joints	1%	60 gal.
Collinsville	Annually	Microphone	90	Various	....	Services	......	....
Duncan	Every 6 mos.	None	75	......	....	......	......	....
Guthrie	None	Microphone	100	None	....	Lead pipe—Electrolysis	......	40 gal.
Mangum	None	Sonoscope	75	None	....	Broken pipe	......	100 gal.
Muskogee	None	......	100	Shows on surface	....	Joints	Not much	....
Tuskahoma	Continually	None	None	Surface indications	Monthly	Pipes	5,000 gal.	100 gal.
Woodward	None		95	......	....	......	......	....
Oregon:								
Albany	None	None	20	Shows on surface	....	Joints	......	95 gal.
Corvallis	None	......	100	Microphone, surface indications	Continuously	Joints	......	175 gal.
Marshfield	Annually	Geophone	10	Geophone	Twice a year	Joints, services	......	100 gal.
Pennsylvania								
Allentown	Annually	Microphone	1.4	Shows on surface	....	Joints	......	122 gal.
Ambler	Every 6 mos.	......	100	......	....	Lead joints	100,000 gal. a day	100 gal.
Ambridge	Quarterly	Darley	100	Microphone	Annually	Services at main	......	21 gal.
Beaver	Every 6 mos.	Electric leak locator	None	Electric leak locator	Annually	Service joints	......	....
Brackenridge	Monthly	Leak detector	80	Recording gauge, leak detector	....	Broken services	......	....
Chambersburg	Quarterly	Microphone	100	Microphone	Annually	Joints	......	....
Coatesville	Every 3 yrs.	Darley leak locator	12	Leak locator	....	Broken pipe in old mains	Very small	120 gal.
Connellsville	Every 2 or 3 yrs	......	35	Microphone, watch sewers, survey	Every few yrs.	Joints	Very few	....
Duquesne	Annually	Meter readings monthly	100	Microphone		Joints		31 gal.
Ellwood City	None	Shows on surface	100	Shows on surface	....	Joints, cracked pipe	......	....
Franklin	Quarterly	......	10	Listening	....	Mains	......	85 gal.
Freeport	None	Aquaphone	10	Listening	....	Joints, valves	......	....
Grove City	Quarterly	None	100	Shows on surface	....	Hydrants	......	9 gal.
Hanover	None	Darley leak locator, aquaphone	5	Darley leak locator	....	Joints	......	90 gal.

Hollidaysburg	None	......	None	......	....	Joints	......	....
Honesdale	Semi-annually	Electric leak locator	15	Darley electric locator	....	Joints, valve stems	......	....
Huntingdon	Not regularly	......	Commercial	Listening	Quarterly	Joints	......	100 gal.
Indiana	Quarterly		90	......	....	......	......	40 gal.
Jenkintown	None	Leak detector	99		....	Broken pipe	3 last year	....
Jersey Shore	Annually	Leak detector	5	Leak detector	....	Joints	Considerable	150 gal.
Johnsonby	Annually	......	10	......	....	......	......	....
Juniata	Annually	None	3 meters	......	....	Joints	......	....
Kittanning	Every 2 yrs.	Earphone, electric leak locator	All industrial	Electric leak locator in street, ear phone on hydrants and service cocks	Every 6 mos.	Broken pipe	2 last year	200 gal.
Lancaster	Annually	Sonoscope	63	Electric leak detector	....	Joints, broken pipe	......	142 gal.
Lebanon	Every 2 or 3 yrs	Microphone, electric leak locator	5	Pitometer	Occasionally	Joints	......	100 gal.
Lehighton	When needed	Sonoscopes	1	Electric leak locator	....	Joints	115,000 gal. in 1924	200 gal.
McDonald	None	......	99	None	....	Broken pipe	......	80 gal.
Mauch Chunk	Occasionally	......	Few	Listening	....	......	......	....
Meadville	Quarterly	Microphone	100	None	....	......	......	126 gal.[p]
Meyersdale	Annually	Microphone	100	......	Twice a year[r]	Joints	......	....
Midland	None	Listening	100	Listening, pitometer	Annually	Services, old iron pipe	200,000 gal. a day	86 gal.
Millville	Twice a year	......	None	None	....	Hydrants	......	....
Minersville	When water scarce	Leak detector	Large consumers	Detector	....	Joints (caused by settling over mines)	......	....
Monaca	Quarterly	None	100	None	....	Joints, fire hydrants	......	....
Mt. Carmel	Twice a year	Aquaphone	30	Aquaphone on valves and services	....	Joints, broken pipe	......	30 gal.
Norristown	Not general	Microphone	....	......	....	Broken pipe	......	120 gal.
North East	Occasionally	None	100	None	....	Services	......	140 gal.
Pittsburgh	Not regularly	General inspection	47.7	Inspection	Continuously	Joints	......	....
Red Lion	Annually	......	Factories	Microphone	Annually	Joints, broken pipe	3 in 1924	....
Ridgway	None		97	None		Joints	......	90 gal.
Sayre	Annually	Microphone, detector	50	None	....	Joints	......	....
Sewickley	Annually	None	94	Darley leak locator	....	Joints	......	241 gal.
Shamokin	Semi-annually	Microphone	Industrial	Microphone	....	Joints	100,000 gal. a day	125 gal.
Sharpsville	Quarterly	Sonoscope, recording gauge	100	Sonoscope at hydrants	Quarterly	Broken pipe, services	2 in 1924	....
Somerset	Quarterly	Sonoscope	100	Bar and sonoscope	Annually	Broken services	......	....
Summit Hill	Quarterly[d]	Wireless leak locator	83	Shows on surface	....	Corporation cocks	......	20 gal.
Susquehanna	Annually	Listening	25	......	....	Wipe-joint goosenecks	......	100 gal.
Tamaqua	Annually	Aquaphone, Darley leak detector	None	Darley leak locator	....	......	......	....
Uniontown	None	Aquaphone	99	None		Broken pipe		....
Warren	None	Aquaphone	90	Aquaphone	6 to 12 mos.	Joints, hydrants	......	95 gal.
Wellsboro	Annually	Microphone	3	Listening at night	Annually	Joints	4 or 5 a year	100 gal.
West Newton	None	Microphone	100	Microphone	Occasionally	Joints	......	50 gal.
Wilkinsburg	None	Microphone	100	Pitometer survey	Annually	......	......	....
Rhode Island:								
Anthony	Occasionally	Microphone	58	None regularly	....	Joints	......	....
East Providence	Quarterly	Aquaphone	90	Pitometer survey in 1924	....	Joints	......	....
Narragansett and South Kingstown	Occasionally	......	20	......	....	Joints	......	....
Pawtucket	None	......	95	Pitometer survey in 1924	....	Dead services	100,000 gal. a day	91 gal.
Westerly	None	......	93.5	Detectaphone, closing valves	....	Joints, valves	Very little	70 gal.
Woonsocket	6 to 12 mos.	Microphone, meter readings	98	Microphone	Annually	Joints, services	......	53 gal.
South Carolina:								
Bennettsville	None	......	100	Check pumpage against meters	....	Joints	......	50 gal.
Charleston	None	Check with master meters	100	Pitometer surveys	Every 2 years	Broken mains, services	Little	75 gal.
Cheraw	None	......	100	Shows on surface	....	......	......	70 gal.
Columbia	None	None	100	Waste survey in 1925	....	184 service leaks, 35 in mains	......	....
Spartanburg	None	None	100	None	....	Lead connections	......	100 gal.

(To be continued)

[a]—Several large consumers use 1 to 3 million gallons each. [b]—All but hospitals, churches and city toilets. [c]—Except municipal use. [d]—When reading meters. [e]—yard hydrants yearly. [f]Most of this used for industrial and sewage purposes. [g]—Two inspectors employed in examining house fixtures only. [h]—Expect to be 100% metered within 60 days. [i]—Water is so muddy that use of domestic meters is impossible; expect to have filter plant in operation this year. [k]—Per consumer. [l]—All except fire services. [m]—Meters discontinued because sand filled them. [n]—Per service. [p]—29 gal. per domestic consumer. [r]—Transmission mains only. [s]—43 gal. in November to 85 gal. in July. [t]—In summer. [u]—210 gal. if railroad use be included.

Garbage Decision Adverse to Piggery

Court grants injunction against pig farm maintained by Lansing, Mich., in an adjoining township and county, although the operation has been the best possible

By Edward D. Rich, C. E.*

A decision which, if affirmed by the Supreme Court of Michigan, will be of great importance to engineers and municipalities interested in pig feeding as a method of garbage disposal, was handed down on February 16, 1925, by Judge R. R. McPeek of the Circuit Court of Eaton county, Michigan.

For several years the garbage of the city of Lansing was fed to swine on a limited area of ground lying within the city limits and adjacent to Grand river. It was impossible to keep a sufficient number of hogs and the disposal of surplus and rejected garbage offered serious problems on this limited area, and the results were highly unsatisfactory. In 1921 the city purchased a farm of 120 acres about a mile west of the county line between Ingham and Eaton counties. This property is situated in a high-grade farming country. To the west there were no very near neighbors but on the north there were three whose homes were directly across the road from the property.

From a thousand to fifteen hundred pigs are yarded on about eight acres near the center of the property. Feeding houses with concrete floors and sleeping quarters in separate buildings are provided. During the day time the hogs are allowed the freedom of the eight acres. A building for can washing and storage is also located within this yard. The soil is of clay loam and the entire yard is scraped once a week with a road machine and the scrapings disposed of. All feeding is done inside of closed buildings with no sewerage connections. Can washing is done inside of a building with a sewer connection. Two concrete pools to obviate the necessity of hog wallows were constructed in the open. These have sewer connections. Garbage is dumped from the cans on to the feeding floors after which the hogs are admitted. After the garbage has been thoroughly worked over by the pigs the residue is heavily limed and taken out in dump wagons. At first it was dumped in piles on adjacent fields and subsequently spread and plowed into the ground for fertilizer. Later it was distributed by means of manure spreaders and allowed to dry out on the ground. All this refuse material is very thoroughly supplied with lime whatever the operation of removal may be.

I visited the piggery a number of times and was surprised to see how completely the garbage odors had been counteracted by the lime treatment. Almost no odors could be detected. However, when the old piles were spread for plowing highly objectionable odors were released. The application of this material to the land has been of very great value as a fertilizer.

As soon as the city of Lansing decided to locate its piggery outside of the city limits and outside of Ingham county it met with opposition from the neighboring farmers who sought an injunction in court to prevent the establishment of the piggery in that locality. This petition was denied on the ground that no nuisance had been created. Suit was again brought in the Circuit Court of Eaton County with action favorable to the plaintiff on the date above mentioned. The plaintiffs swore 68 witnesses. Some stated that social calls in the neighborhood were curtailed on account of the odors. Some farmers stated that they were obliged to discontinue work in certain fields at certain times. Windows had to be closed at night particularly in warm weather. Nausea was produced. Odors were carried more than a mile. There was an increase in flies on the neighboring farms, particularly of the blow-fly type.

There are indications to support the belief that many of these witnesses magnified a rather trifling annoyance into an intolerable nuisance, Resentment against Lansing garbage being disposed of in another township and county undoubtedly played its part in the attitude of the complainants. Judge McPeek granted the injunction on the ground that the neighbors had been damaged in the enjoyment of their homes and that the value of their property had been decreasd.

The methods of operation of the piggery are admitted to have been of the best. Every reasonable suggestion for improvements had been heartily complied with. This case represents what may be expected logically as a result of pig feeding in a well settled locality. I believe the city of Lansing made a mistake when it chose to place its piggery in such a high-grade farming district and really invited trouble by short-sightedness.

Engineers and municipal officials should take warning from these experiences. Even with the best of operation, some slight odors and objectionable conditions are bound to arise from a piggery and the greatest care should be used in selecting a location where these objections cannot be fastened upon by the neighbors to compel the removal of the plant.

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Recent Legal Decisions

MUNICIPALITY OPERATING WATER AND LIGHT PLANTS HELD ENTITLED TO DEAL IN SUPPLIES

The Kentucky Court of Appeals holds, City of Mayfield v. Phipps, 263 S. W. 37, that if a municipality legally acquires a public utility plant, with the right to operate, it would acquire as an incident thereto the right to do everything a private person might do to furnish the citizen with the product, and a municipality which owns and operates within its limits a waterworks and an electric plant was held to have the power incident to such ownership and operation to install the necessary plumbing and electrical equipment and furnish the material therefor, and to pay for such work and material out of the funds derived from such operation. Whether to do so would be a wise policy the court said it was not called upon to decide.

CITY RIGHT, UNDER CONTRACT, TO SUPPLY FROM PRIVATE ARTESIAN WELL

An offer by a landowner to allow a city to connect its waterworks with an artesian well on his land if the city would furnish him with water free of charge, was accepted and acted upon for more than 20 years. By accepting the offer the city avoided the expense of sinking a well on its own land. It incurred only an inconsiderable expense on the faith of the offer. The agreement was not in writing, and its duration was not specified. The Minnesota Supreme Court, held, City of Hutchinson v. Wegner, 195 N. W. 535, in an action by the city to enjoin the landowner from cutting off the flow of water into its mains, that all the city got was a license which was revocable at the will of the landowner and his grantee. But upon the revocation of such a license, it was held that the licensee should be given a reasonable time to secure a supply of water from other sources before the landowner is permitted to shut off the flow of water.

CITY'S RIGHT TO USE OLD PAVING MATERIAL

The Arkansas Supreme Court holds, Williams v. City of Ft. Smith, 263 S. W. 397, that an improvement district is but an agency for the purpose of constructing the improvement. It gains no proprietary interest in the street, and whatever control is given to it for the purpose of making the improvement ceases upon the completion of the improvement. The authority of the municipality over the street does not pass away from it on account of the authority given to the improvement district for a special purpose. Neither do the taxpayers of the district, as such, or as abutting owners, gain any proprietary interest in the street or in the material used by reason of the fact that the improvement was constructed and paid for by taxation on the benefits to adjacent property. It is immaterial whether the city owns the fee or merely an easement. The city's continuous control over the street carries with it the right to make use of discarded old material. The city, it was held, may use old bricks discarded from one street to repave another street in a district having different boundaries from a former district which paved the first street.

CONTINUANCE OF HIGHWAY DISTRICT—TIME TO PRESENT PETITION

The Arkansas Supreme Court holds, Bost v. Road Improvement Dist. No. 4 of Pope County, 260 S. W. 724, that a provision in a statute that petitions for an election as to the continued existence of a highway district must be presented within 30 days from the date the statute went into effect is not so unreasonable as to time as to render the statute void, since all persons are chargeable with constructive notice of the enactment of statutes.

CITY NOT PREVENTED FROM SELLING WATER OUTSIDE LIMITS BY CONTRACT PROVISION

The New Jersey Court of Chancery holds, East Jersey Water Co. v. City of Newark, 125 Atl. 578, that on the exercise by a city of its option to purchase waterworks under a contract which provided that the city should sell water only to persons within a specified area, the city had a right to sell its excess water elsewhere, regardless of the provision, which was held illegal as in restraint of trade. If the water company was injured, by the fact that it was not selling water in communities outside the limited territory, and the city was, it was held to have an adequate remedy by action, since the amount of water delivered by the city and its value could be ascertained.

RECOVERY ON QUANTUM MERUIT FOR PREPARATION OF ENGINEER'S PLANS

The Arkansas Supreme Court holds, Road Improvement Dist. No. 2, Johnson County v. Burkett, 260 S. W. 718, that in a suit by an engineer to recover on quantum meruit the value of preliminary plans made for a road district created by a valid statute, a fair method of ascertaining their value was to ascertain the reasonable cost of the work necessary to prepare the plans, including a preliminary survey, although the survey had been contracted for under a prior unconstitutional act.

RULE AS TO PERMANENCY OF NUISANCE NOT APPLICABLE TO OPERATION OF MUNICIPAL SEWAGE DISPOSAL PLANT

The Texas Court of Civil Appeals holds, City of Austin v. Bush, 260 S. W. 300, that, while it is a general rule that a nuisance may be considered permanent in character where intended to remain in the condition in which it was erected until destroyed by the elements, and the damages are to the land itself, especially where the erection is for a public or semi-public purpose, this rule is not applicable where complaint is made, not to the erection of a municipal sewage disposal plant, but to its operation, which caused the escape of obnoxious fumes; and proof show-

ing the effort to remedy the evil was held to make it a temporary nuisance. Where the defendant city's denial put in issue the permanency of the nuisance, the plaintiff was held not entitled to recover where the findings of the jury did not embrace a finding of permanency, where the plaintiff in his petition based his right of action upon the existence of a permanent nuisance.

EXCLUDING CERTAIN STREETS FROM MOTOR BUS TRAFFIC

The Texas Court of Civil Appeals holds, Waid v. City of Fort Worth, 258 S. W. 1114, that a city is not precluded from denying the use of certain streets to motor buses held to be so congested as to nessitate the exclusion, on the contention of inter-city bus companies that it would destroy their business by increasing the time of travel by 15 minutes.

TOWN NOT LIABLE FOR UNAUTHORIZED ACTS OF ITS OFFICIALS

The Arkansas Supreme Court holds, Road Improvement Dist. No. 1 v. McAlpin, 260 S. W. 423, that an unincorporated town is not liable in damages for the unauthorized acts of its marshal or other official in moving a fence and cuting a levee, resulting in the floding of plaintiff's lands.

WHERE DISCONNECTED STREET IMPROVEMENTS HELD A SINGLE PROJECT

The Arkansas Supreme Court holds, Cooper v. Hogan, 260 S. W. 25, that the determination of a city council as to the singleness and unity of a street paving project, in including property in the improvement district, as well as the selection of the property to be benefited thereby, is conclusive, except for fraud or demonstrable mistake. It was held not to be an objection that the streets designated to be paved were disconnected with each other where they were connected with the other paved streets, and the improvement when completed would constitute a solid area of paved streets.

METHODS OF MEASURING EXCAVATION—SETTLEMENT WHERE WORK TAKEN OVER BY DISTRICT FOR DELAY

An excavation contract provided that the amount of material excavated should be measured in its original position by cross-sectioning unless the engineer should elect to cross-section the embankments after the material was placed, in which event he should provide for a shrinkage of 10 per cent. The Supreme Court of Arkansas held, Mullins & Kyte v. Road Improvement Dist. No. 5, 258 S. W. 639, that the 10 per cent. should be subtracted from the measurement of the roadbed, and not added to it, the measurements being made while the earth was fresh and newly placed and common observation and experience showing that fresh earth packs and shrinks.

The contract provided that if the road district took over the work on the contractors' default, the contractors should receive the difference between the expense incurred by the board in completion and what it would have cost if completed by the contractor, should that be less than the contract price, but if the expense should exceed what would have been payable under the contract, then the contractors and their sureties should be liable for the excess. The work was taken over because of the contractors' delay. A finding of the trial court that there was a profit of 10 cents per cubic yard in the unfinished embankment was sustained on appeal, and the contractors were allowed credit therefor.

The contractors were not held liable for liquidated damages for the delay, where that was mainly caused by unprecedented rainfall and changes in the plans. Costs in the contractors' suit to enjoin the cancellation of the contract were divided equally between the parties.

MUNICIPALITY'S RIGHT TO MAKE EXCLUSIVE CONTRACT FOR HAULING GARBAGE

The Texas Court of Civil Appeals holds, City of Breckenridge v. McMullen, 258 S. W. 1099, that a municipality may prescribe what constitutes a nuisance, and such determination should be upheld in doubtful cases where a certain thing may or may not be a nuisance, depending upon a variety of circumstances requiring judgment and discretion upon the part of the city authorities, in the exercise of their functions. A city was held to have authority to classify certain specified matter as garbage and to prohibit any one but a licensed officer from hauling it. The municipal authorities had the power and right to make a contract with a particular person, giving him exclusive right to haul all the garbage in the city, and providing the fee or charges to be made for such hauling, etc.

CITY'S LIABILITY FOR DUMPING GROUND

The Texas Court of Civil Appeals holds, City of Bowie v. Hill, 258 S. W. 568, that a city which establishes and maintains a dumping ground constituting a nuisance is liable for damages to adjacent property owners caused by deposits by third persons. In a case of this kind, it is held for the jury to determine whether the nuisance is permanent or is so treated by the parties.

CLERICAL ERROR HELD NOT TO INVALIDATE STREET IMPROVEMENT DISTRICT ORDINANCE

The Arkansas Supreme Court hold, Buchanan v. Street Improvement Dist. No. 4, 258 S. W. 989, that a mere clerical error in the description in a second petition for a street improvement district describing one street as west instead of east of certain lots, which would have located it outside of the city limits, did not invalidate the ordinance creating the improvement district.

CONTRACTORS MUST SEE THAT CITY'S BUILDING FUND WILL MEET THEIR CONTRACT

The Arizona Supreme Court holds, City of Yama v. English, 226 Pac. 531, that where contractors were fully informed before their contract was made concerning the financial condition and resources of the city, and the source from which the funds to construct the city hall were to be derived, they were estopped from objecting, after the complete execution of the contract, that there were not sufficient funds in the city's building fund to meet the entire contract price.